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U.S. ECONOMIC GROWTH FROM 1976 TO 1986: PROSPECTS, PROBLEMS, AND PATTERNS

Volume 6—Forecasts of Long-Run Economic Growth

STUDIES

PREPARED FOR THE USE OF THE

JOINT ECONOMIC COMMITTEE
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LETTERS OF TRANSMITTAL

DECEMBER 10, 1976.

To the Members of the Joint Economic Committee:

Transmitted herewith is the sixth volume of the Joint Economic Committee study series entitled "U.S. Economic Growth from 1976–1986: Prospects, Problems, and Patterns." This series of over forty studies forms an important part of the Joint Economic Committee's Thirtieth Anniversary study series, which was undertaken to provide insight to the Members of Congress and to the public at large on the important subject of full employment and economic growth. The Employment Act of 1946, which established the Joint Economic Committee, requires that the committee make reports and recommendations to the Congress on the subject of maximizing employing, production and purchasing power.

Volume 6, a key one in the series, contains three papers which present the latest forecasts of long-run economic growth in the United States as well as analysis of the models that generate these forecasts. Private as well as Federal Government forecasts are examined. Also, in addition to the standard econometric models used for projections, two of the papers discuss the newer system dynamics model which has potential use in economic forecasting.

The authors of the studies in this volume are Dr. Gary Fromm, Professor Nathaniel Mass and Professor Jay Forrester, and Dr. Joseph W. Duncan. The committee is grateful to these authors for their fine contributions, all of which are highly informative and stimulative.

The views expressed are those of the authors and do not necessarily represent the views of the Members of the committee or the committee staff.

Sincerely,

HUBERT H. HUMPHREY,
Chairman, Joint Economic Committee.

DECEMBER 6, 1976.

Hon. HUBERT H. HUMPHREY,
Chairman, Joint Economic Committee,
U.S. Congress, Washington, D.C.

DEAR MR. CHAIRMAN: Transmitted herewith are three studies entitled "Forecasts of Long-Run Economic Growth," by Dr. Gary Fromm, "Understanding the Changing Basis for Economic Growth in the United States," by Prof. Nathaniel Mass and Prof. Jay Forrester, and "Long-Term Economic Growth Forecasts in the Federal Government," by Dr. Joseph W. Duncan.

These three studies comprise volume 6 of the Joint Economic Committee's study series, *U.S. Economic Growth from 1976–1986: Prospects, Problems and Patterns.* This series forms a substantial part of the Joint Economic Commitee's Thirtieth Anniversary study series.

Each of these papers examines modelling efforts which have been devised to yield projections of economic growth over the long run. Not only are the forecasts presented, but the papers take an in-depth, "behind-the-scenes" look at the basic structure and methodology of the models which is very useful in terms of understanding why the models so often yield very different results. Two of the papers also present illuminating discussions which contrast the more traditional econometric model approach with the newer system dynamics approach.

The paper by Dr. Fromm contains a comprehensive review of the major long-term economic growth forecasting efforts in the private sector. Nearly half of the paper is devoted to a discussion of the alternative projection methods: Simple extrapolation, reduced form projection, system dynamics and feedback control models, and econometric models. Pointing out the problems associated with relying on any one of these techniques at this time, he concludes that more structurally realistic and accurate models can be built in the future. Most of the forecasts present a favorable picture for output, inflation and income over the next 10 years with growth rates projected to exceed those of most 5- and 10-year post recession intervals during the years subsequent to World War II. The median forecast for the annual compound growth rate for real GNP is 4.8 percent for 1975–80 and 3.5 percent for 1980–85.

The paper by Mass and Forrester is challenging in that it presents a hypothesis concerning long-run economic growth that is not widely shared. They contend that the greater instability in the economy appears to be caused by two principal modes of economic behavior whose existence is not widely recognized and whose causes are only poorly understood: The Kondratieff cycle, or long wave, and the life cycle of economic development. The significance of the long-wave phenomenon to public policies lies in the fact that, if the long wave is a real recurring element of the national economy, then the United States may be approaching another trough of the approximately fifty year cycle. The problem, as the authors see it, is that economic stabilization policy today is predicated chiefly on prevailing theories of the short-term business cycle, whereas current economic developments probably arise from the interaction of both short- and long-term modes of economic behavior. Ten recommendations related to national policy regarding economic growth—including expanding the time frame of stabilization policy, abandoning the Phillips curve concept as an indicator for public policy and conducting increased research into the dynamics of the national economy—are presented which take into account these hypothesized longer term phenomena.

The paper by Dr. Duncan describes the major ongoing economic forecasting models developed by major Federal agencies. Each of the major models related to economic growth is described in terms of its basic structure, the most recent findings, and the users of the forecasts. The paper examines the degree of coordination between forecasting groups of various agencies, concluding that there is a high degree

of informal coordination, but that there is a growing need for more formal coordination efforts. Another of its major points is that the establishment of a central economic forecasting model would be counterproductive and too constricting in developing helpful decision-making tools.

The committee is indebted to these authors for their work in developing these highly informative papers for this study series. Dr. Fromm is an economist with the Stanford Research Institute and the National Bureau of Economic Research, Professors Mass and Forrester are at MIT, where they serve both as faculty members and as members of the System Dynamics National Modeling Project, and Dr. Duncan is the Deputy Associate Director for Statistical Policy at the Office of Management and Budget.

Dr. Robert Hamrin of the committee staff is responsible for the planning and compilation of this study series with suggestions from other members of the staff. The administrative assistance of Beverly Mitchell of the committee staff is also appreciated.

The views expressed are those of the authors and do not necessarily represent the views of the Members of the committee or the committee staff.

Sincerely,

JOHN R. STARK,
Executive Director,
Joint Economic Committee.

CONTENTS

FORECASTS OF LONG-RUN ECONOMIC GROWTH*

By Gary Fromm**

Introduction and Summary

During the past decade there has been much public discussion about the desirability of reducing U.S. economic growth and that of other highly developed countries so as to conserve environmental and natural resource assets and improve the quality of life by lowering tensions associated with strong pursuit of material well-being. More recently, with a world-wide slowdown in growth rates and a severe recession in 1975, concerns about low growth have surfaced anew, especially with the realization that changing demographic patterns (an aging population) and lower productivity (for reasons to be explained) might limit possibilities for transfers from the young to the old or disabled via health and income security outlays and from the rich to the poor via redistribution of tax burdens. With high growth and rapidly increasing income and wealth per capita, more equal sharing of a rising prosperity is politically more feasible and more easily accomplished. Standards of living of those most disadvantaged by accidents of birth, age, health, past discrimination, or other social conditions, can significantly be raised while making everyone better off, or at least no worse off. In economists' terms, high growth accommodates Pareto efficiency. High growth is not necessary, nor even sufficient to guarantee ease of redistribution, but it surely helps. Apart from redistribution it also permits devoting substantially more resources to improvements in environment, public health and safety, arts and the humanities, education, national security, foreign aid, and other socially useful purposes. Still, the picture is not one-sided and there probably are many persons who would opt for a low-growth scenario. However, whatever one's preferences, the elements which influence growth and its prospects should be examined carefully so that suitable policies can be considered and appropriate choices made among alternative growth strategies.

Methods for projecting growth vary greatly in sophistication, structural detail, dynamic characteristics and costs. The simplest, quickest and cheapest, and perhaps least accurate, are extrapolations of past performance. These contain little or no structural or causal interactions and depend mainly on observed empirical regularities. Forecasts in this category include those based on combination of periodic short- and long-run swings of population growth and business activity—the

*Paper prepared for U.S. Joint Economic Committee study series, U.S. Economic Growth from 1976–1986: Prospects, Problems and Patterns. This research was in part supported by the National Science Foundation. I am indebted to E. C. Hwa and Milton Kelenson for valuable assistance and to the individuals and organizations who kindly supplied forecasts.

**Member and Senior Research Staff, National Bureau of Economic Research, and Director, Center for Economic Policy Research, Washington, D.C., Stanford Research Institute.

Metzler, Kitchin, Juglar, Kuznets, and Kondratieff cycles—and those based wholly on autoregressive-integrated moving average statistical fits to historical growth rate data.

Reduced form growth models in which predictions depend on some causal linkages but are driven largely if not exclusively by exogenous forces are somewhat more costly than extrapolative techniques. However, they should be more reliable because normally they incorporate information on labor force participation, unemployment, and productivity, all of which have strong influences on growth. The principal deficiency of the reduced form approach is that it obscures dynamic interactions and endogenous causal or behavioral linkages which are determinants of growth.

In contrast, systems dynamics and feedback control models place primary emphasis on assumed, detailed patterns of behavior and their time sequences. Little, if any allowance is made for exogenous influences and predicted growth paths are determined almost solely by the mathematical characteristics of the model. The systems dynamics approach, at least as implemented until now, utilizes little data on the actual path of the economy but relies on extensive, intensive, and costly computer simulation to develop growth scenarios. The strength of the technique is its emphasis on dynamics and behavior; its weakness, as currently implemented, is the failure to allow adequately for external forces and shocks and sufficiently to undertake validation tests, especially those of comparing predicted and actual performance.

Econometric models share many of the characteristics of systems dynamics models in their emphasis on causal linkages and time varying paths. They differ in grounding their behavioral specifications in economic theory and in a more rigorous approach in delineating structural relationships. Parameters of equations largely are estimated by "fitting" historical data using a variety of statistical methods. In general, too, most econometric models are subjected to batteries of tests to ascertain their predictive accuracy and response patterns to shifts in policy variables and parameters. Data requirements and costs are the primary drawback of this forecasting technique, especially when the model is large in scale. Yet, given the value of accurate predictions in enabling improved formulation of government policies, the costs might be considered negligible.

Forecasts of U.S. economic growth over the 1975–85 interval were obtained from 22 organizations. While the sample is limited, the predictions are felt to be representative of the "best" and currently most widely used U.S. economic projections for the next decade. Most of the forecasts assume that fiscal and monetary policy will neither be highly stimulative nor restrictive and will steer a middle course which permits the private sector to grow at its own natural rate. But, some of the respondents anticipate a moderate or growth recession during 1977–79, largely due to a tight monetary policy in 1977–78. The median prediction for real GNP growth for 1975–80 is 4.8 percent per annum and for 1980–85 is 3.5 percent. Inflation during the first five years is projected at a 5.7 percent annual rate and in the first half of the 1980's at 5.0 percent. Unemployment rates for the remainder of this decade are predicted to average 6.5 percent and then fall to 5.0 percent for 1981–85.

This scenario is more favorable than that of the last five years. But, it is subject to a number of major uncertainties, including errors in fiscal and monetary policy management, potential capacity shortages brought about by poor financial structure of capital intensive industries, and the effects of possible shocks from cartels, world food shortages, military or political upheavals, or other unanticipated sources. A successful growth outcome will depend upon pursuit of a galaxy of policies designed to affect both demand and supply and to maintain proper balance between them. Better analytical tools are needed to achieve that end and government-sponsored research for that purpose should be given high priority.

Alternative Projection Methods

Naive Extrapolation

The variety of techniques for predicting growth is great, ranging from simplistic extrapolation of past performance to exhaustive, highly detailed structural annalyses. At the bottom end of the spectrum, there is the naive method of using averages of output growth over long intervals or over the recent past. For example, real GNP grew at the following annual compoud rates over the stated intervals (measured in 1972 prices) :

	Percent
1930–75	3.29
1940–75	3.61
1950–75	3.27
1960–75	3.26
1965–75	2.56
1965–70	3.04
1970–75	2.08

Last year, 1975, of course was one of deep recession; using this as a terminal date would tend to lower growth rates depending on whether the initial year was at a cyclical peak or trough and the length of the interval over which the growth rates are calculated. The longer the time span, the less the effect of initial and terminal year boom-recession conditions. Still, end-year conditions can make significant differences for growth measurement.

This is evident by inspection of real growth rates over succeeding five year intervals. (See table 1.) For example, starting in 1950, the real growth rate drops from 4.2 percent for the 1950–55 period to 3.3 percent for the ten-year span 1950–60, and then rises to 3.7 percent for the fifteen year interval 1950–65. It then falls to 3.6 and 3.3 percent for the 1950–70 and 1950–75 periods, respectively. With a starting point of the boom year 1955, the pattern is similar but the 20-year growth rate (1955–75) is only 3.0 percent. Over shorter intervals, differences in growth rates tend to be even greater.

TABLE 1.—COMPOUND ANNUAL GROWTH RATES OF REAL GNP

[In percent]

	[1] 1930	1935	1940	[1] 1945	1950	1955	[1] 1960	1965	[1] 1970
1935	−1.6								
1940 [1]	2.2	6.0							
1945 [1]	4.5	7.7	9.4						
1950	3.3	5.0	4.5	−0.2					
1955	3.5	4.8	4.4	2.0	4.2				
1960 [2]	3.3	4.3	3.9	2.1	3.3	2.4			
1965	3.5	4.4	4.0	2.8	3.7	3.5	4.7		
1970 [1]	3.4	4.2	3.9	2.8	3.6	3.4	3.9	3.0	
1975 [1]	3.3	3.9	3.6	2.7	3.3	3.0	3.3	2.6	2.1

[1] Recession year.
[2] Peak prior to 1961 occurred in April 1960.

Note.—Real GNP measured in 1972 dollars.

Therefore, projection of growth rates based on simple extrapolations of past performance are subject to large errors. Compound differences in growth rates can accumulate to large amounts over even short intervals. For instance, the difference between growth rates of 3.5 and 3.0 percent would result in a gap between the two projections of 6.7 percent of real GNP after ten years which, for the 1975–85 period, is nearly sufficient to allow for doubling the Federal budget without any increase in tax rates.

A complication with simple extrapolation of past growth is that increases in output, even when averaged, do not take place along a smooth exponential path but tend to exhibit waves or cycles. This was observed in the 19th century by Clement Juglar, who was the first to isolate major industrial fluctuations of prices, production, employment, and so forth, over a period of nine to ten years.[1] This is one of three cycles used by Joseph Schumpeter in his explanation of capitalist development innovations and the dynamics of economic growth.[2] Of the other two cycles, one is a regular forty month fluctuation named for Joseph Kitchin, who was the first to study it in detail, and the other is a long wave of 50–60 years first identified in 1919–20 by a Russian economist, Nikolai Kondratieff.[3] Taking the types together, there are three Kitchin cycles of 40 months each to every Juglar cycle of 9–10 years and five to six Juglar cycles in every Kondratieff cycle. Underlying phenomena associated with those fluctuations are inventory investment, business fixed investment, innovation and changes in capital accumulation, and opening and expansion of new markets.[4]

[1] This summary description is from Douglas Greenwald and Associates, "Dictionary of Modern Economics," second edition (McGraw-Hill, New York, 1973). For additional details see Joseph A. Schumpeter, "Business Cycles," 2 vols. (McGraw-Hill, New York, 1939).

[2] Ibid.

[3] Joseph Kitchin, "Cycles and Trends in Economic Factors," Review of Economic Statistics, vol. 5, No. 1, February 1923, pp. 10–16. Kondratieff's findings were first published in Moscow in 1922, then in German "Die langen wellen du Konjunktur," Archiv für Sozialwissenschaft and Sozialpolitik," vol. 56, No. 3, 1926, pp. 573–609, and then in English, "The Long Waves in Economic Life", Review of Economic Statistics, vol. 17, No. 6, November 1935, pp. 105–15. The last is reprinted in "Readings in Business Cycle Theory" (Richard D. Irwin, Homewood, Ill., 1951).

[4] For a critical appraisal of Kondratieff cycles see George Garvy "Kondratieff's Theory of Long Cycles," Review of Economic Statistics, vol. 25, No. 4, November 1943, pp. 203–220; also Arthur F. Burns and Wesley C. Mitchell, Measuring Business Cycles (National Bureau of Economic Research, New York, 1946), chapter 11. On Juglar movements see R. C. O. Matthews, The Business Cycle (Chicago, 1959), ch. 12. Many names are associated with work on inventory cycles but most analyses are directly or indirectly related to Lloyd A. Metzler, "The Nature and Stability of Inventory Cycles," Review of Economic Statistics, vol. 23, No. 3, August 1941; reprinted in R. A. Gordon and L. R. Klein (eds.), AEA Readings in Business Cycles (Richard D. Irwin, Homewood, Ill., 1975).

Another phenomenon that has been identified, which has been associated with the name of Simon Kuznets, is an approximate 20-year wave in population growth, which impacts on the demand for residential housing and related public utility and community facilities.[5]

The analyses of Kuznets, Kondratieff, Kitchin, Juglar, and Burns, Mitchell, and others date to the 1930's or earlier and were carried out on U.S. and European data for the 19th and early 20th centuries. The techniques they employed were relatively unsophisticated and to a large degree depended on dating peaks and troughs in moving averages of economic activities. A more rigorous method is to calculate the spectral density of annual growth rates.[6] This was done for U.S. real GNP data for the period 1930–1975; the results are shown in figure 1.[7] They accord roughly with the cycles or swings found by Kitchin, Juglar, and Kuznets. The density function peaks at annual frequencies of 0.5, 0.35, 0.08, and 0.05, corresponding to periodicities (equal to reciprocals of the frequencies) of about 2–3, 12½, and 20 years. The two-year cycle may be attributed in part to a variety of measurement problems, including seasonality, observation errors, and a need for short-run smoothing. The periodicities of about four and 20 years also are consistent with findings from stochastic simulations with the Wharton model using a post-World War II sample period.[8]

Concentrations in the spectral density function may be used to predict future activity levels. However, it should be recognized that there may be significant variances about average periodicities and amplitudes of fluctuations at these periodicities. Moreover, there can be trends and cycles in those magnitudes caused by both deterministic (causal) and stochastic (random) factors. As a consequence, precise path predictions based only on past growth rate experience are subject to considerable error.

This can be seen more readily using a nearly equivalent technique in the time domain to the spectral representation in the frequency domain. Table 2 presents autoregressive, integrated, moving average (ARIMA) models of real GNP growth rates over three sample periods.[9] The results reported were obtained by searching over each sample space (period) for the parameters (p and q) which minimized the standard error of estimate of the ARIMA equation. It is evident that the magnitudes of the parameters shift significantly with changes in sample periods. The same holds true for extrapolations (forecasts) from these equations. (See table 3.)

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[5] See W. Arthur Lewis and Paul J. O'Leary, "Secular Swings in Production and Trade, 1870–1913," The Manchester School of Economic and Social Studies, vol. 13, No. 2, May 1955, pp. 113–52 and Moses Abramowitz, "The Nature and Significance of Kuznets Cycles," Economic Development and Cultural Change, vol. 9, April 1961. Both articles are reprinted in AEA Readings in Business Cycles, op. cit.

[6] Any continuous, stationary (trendless) times series may be transformed into an equivalent linear combination of components in the frequency domain (an analogy is AM and FM radio signals). If all frequency components have equal weight, the spectral density function has a rectangular form. If some components of a time series, after trend is removed, account for more of the total variation than others, this is revealed by a concentration of weights of its spectral density function at those frequencies.

[7] Data used were GNP in 1972 dollars, which kindly were provided by the Bureau of Economic Analysis, U.S. Department of Commerce. These were converted to annual growth rates, 1930–75. The analysis was performed with the spectral subroutine of the NBER TROLL system using a triangular smoothing window, a range of 10 years, prewhitening with a parameter of 0.8, and removal of the mean growth rate of 2.41 percent per annum (its standard deviation is 6.31 percent).

[8] See M. K. Evans, L. R. Klein, and M. Saito, "Short Run Prediction and Long Run Simulation of the Wharton Model," in Bert G. Hickman, ed., Econometric Models of Cyclical Behavior, vol. 1 (National Bureau of Economic Research, New York, 1972), pp. 139–85 and Lawrence R. Klein, A Textbook of Econometrics (Prentice-Hall, Englewood Cliffs, N.J., 1974), pp. 252–9.

[9] For a description and examples of this technique see G. E. P. Box and G. M. Jenkins, Time Series Analysis: Forecasting and Control (Holden Day, San Francisco, 1970).

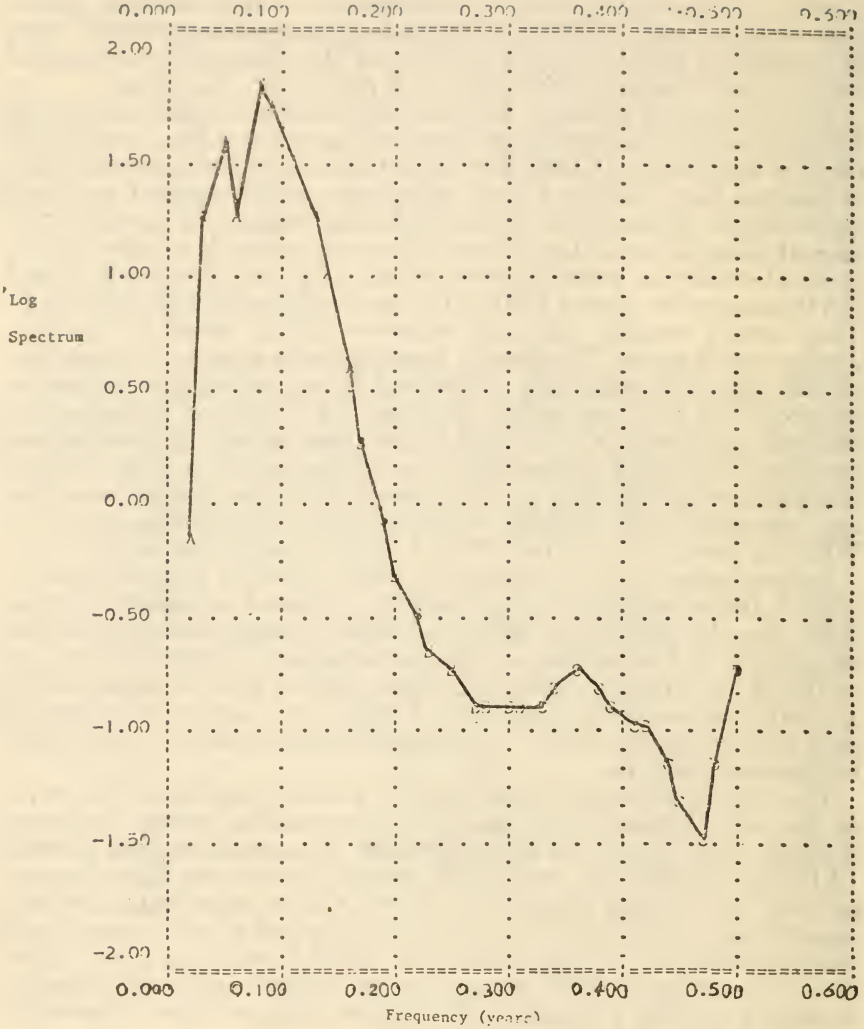


FIGURE 1.—Spectral Density of U.S. Economic Growth Rates: 1930–75.

TABLE 2.—ARIMA MODELS OF REAL GNP ANNUAL GROWTH RATES

$$G(t)=C+\sum_{i=1}^{p}\phi_i G(t-i)+\sum_{j=1}^{q}\theta_j\epsilon(t-j)+\epsilon$$

PARAMETERS AND STATISTICS

Sample period	ϕ_1	ϕ_2	ϕ_3	θ_1	θ_2	C	SER	$\bar{G}(t)$	$\frac{SER}{\bar{G}(t)}$	D.W.
1933–75	0.806	−0.529		0.658	−0.999	2.808	4.036	4.159	0.970	1.64
	(23.5)	(15.4)				(3.9)				
1950–75	−0.145	−0.190	−0.239	−0.255		5.786	2.901	3.512	0.826	1.79
	(0.7)	(0.8)	(1.3)			(3.2)				
1954–75	−0.787	−0.482	−0.454	−0.999		8.377	2.436	3.036	0.802	1.61
	(3.7)	(1.5)	(2.2)			(3.5)				

NOTES

1. Real GNP measured in 1972 dollars.
2. Symbols:
   G(t)=annual rate of change of GNP in 1972 dollars (percent).
   C=constant term.
   ϵ=random error.
   $\bar{G}(t)$=sample mean of G(t).
   SER=standard error of the equation.
   DW=Durbin-Watson statistic.
3. Magnitudes in parentheses underneath respective parameters are t-statistics.

TABLE 3.—ARIMA FORECASTS OF REAL GNP ANNUAL GROWTH RATES: 1976–2000

SAMPLE PERIOD

[Percent]

	1933–75	1950–75	1954–75
Forecast year:			
1976	4.09	4.80	8.17
1977	4.20	5.93	3.61
1978	2.93	4.55	2.43
1979	2.89	2.62	1.01
1980	3.16	2.33	4.77
1981	3.17	3.57	3.02
1982	3.12	3.98	3.23
1983	3.11	3.72	2.21
1984	3.13	3.46	3.71
1985	3.13	3.43	2.93
1986	3.12	3.56	3.28
1987	3.12	3.62	2.70
1998	3.12	3.60	3.34
1989	3.12	3.55	2.96
1990	3.12	3.54	3.21
1991	3.12	3.56	2.90
1992	3.12	3.57	3.20
1993	3.12	3.57	3.00
1994	3.12	3.56	3.15
1995	3.12	3.56	2.99
1996	3.12	3.56	3.14
1997	3.12	3.57	3.03
1998	3.12	3.57	3.12
1999	3.12	3.56	3.09
2000	3.12	3.56	3.11

Note: GNP measured in 1972 dollars. Actual growth rate in 1975 equals −1.83 percent.

Using the equation estimated over the period 1933–75, the extrapolation for 1975–2000 of annual real GNP growth rates (starting from an initial condition of actual experience in 1975 of −1.83 percent) jumps to 4.09 percent in 1976, peaks at 4.20 percent in 1977 and, after two small growth cycles of decreasing amplitude, approaches a steady state rate of 3.12 percent in the late 1980's. Moving to a post-World War II sample period of 1950–75, a similar pattern is evidenced, but the amplitude of cycles is larger. There are four increasingly damped cycles, the steady state is not reached until the late 1990's, and the projected long-term growth rate is 3.56 percent. An even more marked contrast in the extrapolated path results when just

four years are dropped from the beginning of the sample period. Using the interval 1954–75, the amplitude of growth cycles thereafter becomes significantly greater than for the longer sample periods and there are many more, and shorter cycles. However, the steady state is about the same as using the 1933–75 sample period and appears to be stabilizing at the year 2000 around a 3.10 percent growth rate. A comparison of the three growth paths may be found in figure 2.

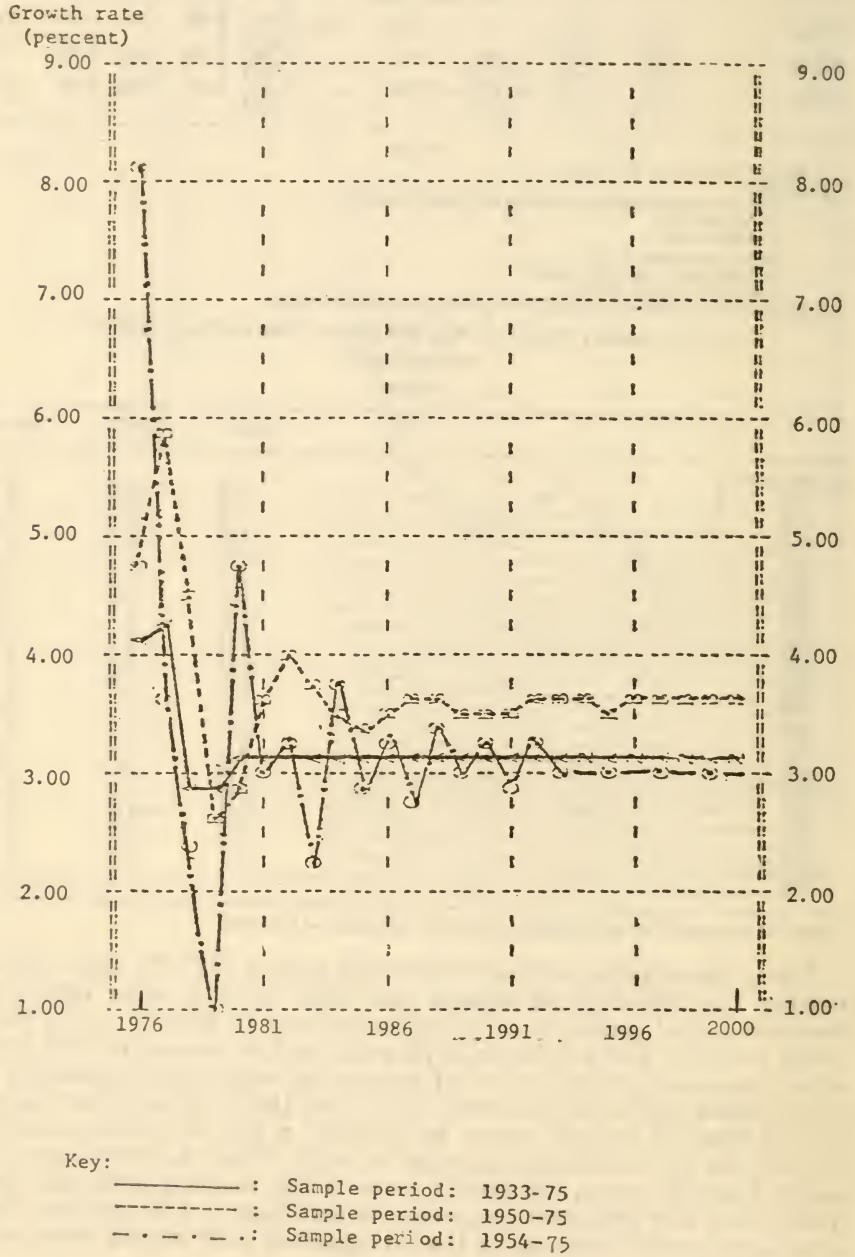


FIGURE 2.—ARIMA Forecasts of Real GNP Annual Growth Rates: 1976–2000.

The steady state projections of these equations should not be interpreted literally. The economy is expected to exhibit continuing growth cycles. But, this is not reflected in the ARIMA forecasts beyond a certain point because of the characteristics of this technique and its dependence on stochastic terms. As the projection moves increasingly beyond the sample period, no further stochastic information is entered and gradual damping takes place through the ARIMA process. The failure to include any structural information other than the historical path heightens this effect.

In general, extrapolation, whether of a naive (such as simple projection of past performance) or sophisticated form (such as single variable ARIMA models) is a poor method of forecasting because it ignores causal factors which may radically alter future characteristics and paths. The variance of prediction errors from these types of forecasts normally will be significantly greater than those from models which account for structural linkages.[10] Use of extrapolation as a forecasting tool can be justified if underlying structural and causal processes are poorly understood or cannot be modeled for reasons of lack of data or expense, or with a prediction accuracy that surpasses that of simpler extrapolation alternatives. This is unlikely to be true in the case of models of long-term growth of the economy.

Reduced Form Prediction

In a reduced form, variables to be predicted are expressed only as functions of exogenous or predetermined information and do not depend simultaneously on each other. Reduced forms can be naive or complex, and can range from single to hundreds of equations. An example of the former is the orthodox monetarist doctrine that the rate of growth of GNP is dependent almost exclusively on the rate of growth of the money supply. While popular in some circles, this theory has not found widespread acceptance. Yet another relatively simple reduced form model has been utilized widely for growth prediction.[11]

It may be characterized as follows. Assume that population is given exogenously. Assume further that labor force participation as a function of population is constant or can be extrapolated as a smooth trend. Next, take a given rate of unemployment as a full employment target and assume that it will be achieved. Then, extrapolate the rate of growth of labor productivity (output per employee) from past data or by other methods. Combining these steps then yields a growth rate. Roughly, if labor force participation and unemployment rates are held constant, the output growth rate is the sum of the population and productivity growth rates. For instance, for the 1975–85 decade the U.S. Bureau of the Census has estimated that population will grow at a compound rate of approximately one percent. For the period 1968–73 (that is, excluding the 1974–5 recession), the annual rate of

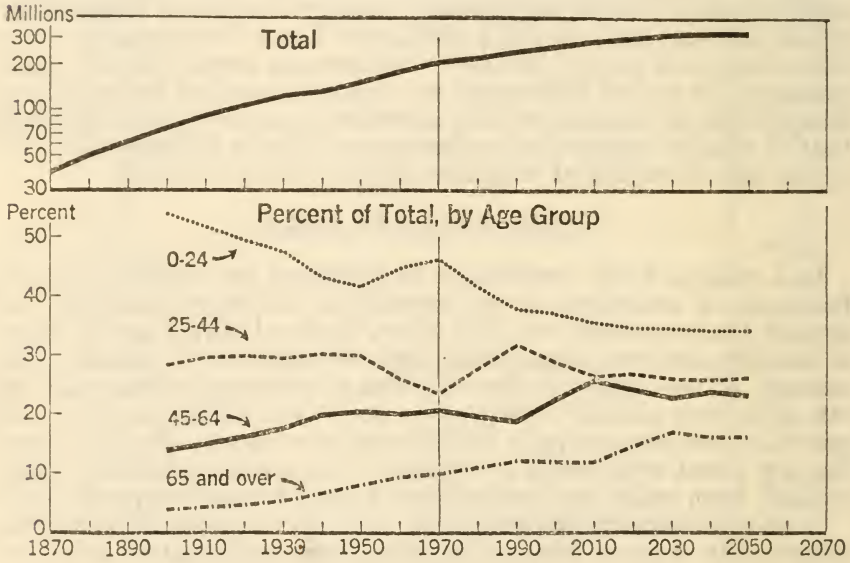
[10] In fact, comparison of extrapolation and structural model forecasting errors is a test of the reliability and potential validity of the models; residuals from the latter should be smaller than those from extrapolation.

[11] For the past 15 years until now, this technique has been the primary basis for U.S. Government estimation of potential output of the economy, see Report of the Council of Economic Advisers, 1962 and subsequent annual issues. It has been utilized in slightly more elaborate form by the Organization for Economic Cooperation and Development (OECD) in The Growth of Output 1960–80; Retrospect, Prospect and Problems of Policy, December 1970, and for several of the forecasts summarized below.

growth of real GNP per employee hour was 1.41 percent.[12] If this same productivity growth were extended to the next decade, then real GNP would be predicted to increase at about a two and one-half percent compound rate.

Actually, labor force participation is expected to increase somewhat in the years ahead due to changing age-composition of the population and to a still rising proportion of women seeking paid employment. (See Figure 3.) Also, for various reasons to be discussed shortly, productivity could well grow faster than it has since 1968. Therefore, barring another severe cyclical downturn or other untoward circumstances, real GNP most likely will rise faster than the two and one-half percent rate just given.

FIGURE 3.—Population of the United States: 1870–2050



NOTE.—1980–2050 Census Estimates, Series II.

Source: Figure provided by Office of the Secretary of the Treasury, Office of Debt Analysis.

A more sophisticated reduced-form growth model underlies the heralded work of Edward F. Denison.[13] As I have observed elsewhere, his technique basically is one in which rates of growth of various inputs are weighed by their earnings share in national income to obtain the contribution of each input to the rate of growth of national income.[14] Denison disaggregates the inputs as well as the overall productivity of their use in great detail. An example of the output of his painstaking efforts may be found in table 4. As can be seen therein, account is taken of capital as well as labor inputs, and allowances are made for age-sex composition, education, shifts in hours, economies

[12] Estimate provided by M. D. McCarthy, Council of Economic Advisers.

[13] See his Accounting for United States Economic Growth 1929–1969 (Brookings Institution, Washington, D.C., 1974).

[14] Gary Fromm, "Review of the Sources of Economic Growth and the Alternatives Before Us," by Edward F. Denison, Journal of the American Statistical Association, vol. 58, No. 304, December 1963, pp. 1168–71.

of scale, irregular influences, and other factors. Still, the dominant characteristics of Denison's approach is that these forces are exogenous and largely independent. In his methodology they are not determined simultaneously, and there are few if any feedbacks. When structural linkages such as interaction between compensation rates, productivity advances, and increases in factor inputs are ignored, the overall effect is likely to lead to biased and inconsistent estimates of the contributions of different elements to growth.

TABLE 4.—SOURCES OF GROWTH OF ACTUAL NATIONAL INCOME, SELECTED PERIODS

[Contributions to growth rate in percentage points]

	1948–53	1953–64	1964–69	1969–80 [1]
National income	4.54	3.23	4.54	4.13
Total factor input	2.95	1.30	3.08	2.39
Labor	2.07	.60	2.15	1.37
General government, households, and institutions	.96	.27	.55	.23
Employment	.91	.31	.51	.24
Hours and shifting weights	.05	−.04	.04	−.01
Nonresidential business	1.11	.33	1.60	1.14
Employment	.72	.20	1.75	1.12
Hours	−.06	−.21	−.24	−.15
Average hours	−.29	−.26	−.45	−.20
Efficiency offset	.12	−.02	.10	.01
Intergroup shifts	.11	.07	.11	.04
Age-sex composition	.07	−.09	−.31	−.05
Correction to hours and age-sex composition	(2)	(2)	(2)	−.08
Education	.38	.43	.40	.30
Capital	.88	.70	.93	1.02
Inventories	.18	.08	.18	.12
Dwellings	.31	.27	.29	.39
Nonresidential structures and equipment	.38	.29	.45	.47
International assets	.01	.06	.01	.04
Land	0	0	0	0
Output per unit of input	1.59	1.93	1.46	1.74
Advances in knowledge and not elsewhere classified	1.34	1.13	1.15	.16
Improved resource allocation	.41	.24	.34	.10
Farm	.33	.21	.19	.07
Nonfarm self-employment	.08	.03	.15	.03
Dwellings occupancy ratio	−.03	−.01	.01	0
Economies of scale	.48	.32	.56	.46
Irregular factors	−.61	.25	−.60	.16
Weather in farming	−.03	−.02	.02	0
Labor disputes	0	0	−.01	0
Intensity of demand	−.58	.27	−.61	.16
Antipollution costs	0	0	0	−.14

[1] Change from actual national income in 1969 to potential national income in 1980.
[2] Not relevant.

Source: Edward F. Denison, "Sources of Growth Accounting as the Basis for Long-Term Projections," in Tigran S. Khachaturov (ed.), "Methods of Long-Term Planning and Forecasting" (International Economic Association, MacMillan Press Ltd., 1976), pp. 241–59.

This is typical of the reduced form approach to prediction. While structural information is incorporated into such models, it is unidirectional, from a set of exogenous forces or assumptions directly to a set of outcomes. This process, too, obscures dynamic interactions and does not constitute an adequate representation of dynamic long-run behavior.[15] In an economic growth context, it is most useful, perhaps, for examinations of past history and for making ballpark estimates and internal consistency checks of future performance.

Systems Dynamics and Feedback Control Models

The systems dynamics approach to modeling growth stands in marked contrast to those of naive extrapolation and reduced form

[15] This also is the conclusion of Phoebus J. Dhrymes, "Econometics: Statistical Foundations and Application" (Springer-Verlag, New York, 1974), p. 508.

methods. In the Forrester-Mass formulation, the model is constructed to depict social and economic change following certain general principles.[16]

These include:

1. Decisionmaking within sectors is modeled widely on observed business and government practices. Behavior in the models is not based on theories of optimal general equilibrium nor on profit or utility maximization or cost minimization.

2. Special attention is given to stocks of inventories, capital, order backlogs, finance, and so forth, and distinctions are made between desired and actual levels. Provision also is made for gradual adjustments toward desired states.

3. Highly nonlinear relationships are incorporated, especially those representing limiting conditions such as capacity constraints and maximum rates of change.

4. Quantitative computer simulation is used to derive qualitative behavior of the system. Policy alternatives are explored by altering parameters of the model and observing consequences for solution paths.

5. The model is wholly self-contained, parameters and structure are fixed, there are no exogenous influences, and stochastic shocks are not admitted or damped very rapidly.

The application of systems dynamic techniques to analysis and prediction of economic performance has much to recommend it. Emphasis on observed behavioral relations can lead to a model which more realistically depicts the actual economy than models which rely heavily on exogenous elements and static equilibrium conditions. Rarely does the world seem to be in equilibrium but rather it appears to be groping from one disequilibrium state to another in the search for dynamic, shifting, equilibrium targets. To the extent that this process is mirrored in a systems dynamics model, it has advantages over models which are based on less realistic premises. On the other hand, the present assumptions of the Forrester-Mass formulation are unduly restrictive and unrealistic in a number of respects, which tends to invalidate conclusions derived from simulations of their model. These assumptions are convenient in that they simplify the modeling process, but they are not necessary.

The most tenuous and least likely characteristic of the Forrester-Mass model is that the structure of the economy either has not changed or if it has, its essential dynamic properties as revealed in cyclical waves—Kondratieff, Kuznets (business), or (in their terms) life cycle—are unaltered. This seems incredible in the light of introduction of automatic stabilizers and the use of discretionary fiscal and monetary policy to abort or avert cyclical episodes. It is farfetched to believe that all economic and political behavior can be made endogenous and that the path of the systems is preordained. Even with a fixed

[16] For a nontechnical overview, see Nathaniel J. Mass, "Modeling Cycles in the National Economy," Technology Review, vol. 78, No. 5, March/April 1976, pp. 42–52. Other descriptions may be found in Jay W. Forrester, "Business Structure, Economic Cycles and National Policy," Systems Dynamics Group Working Paper D–2245–2, Alfred P. Sloan School of Management, M.I.T., Cambridge, 1975, Jay W. Forrester, Nathaniel J. Mass, and Charles J. Ryan, "The Systems Dynamics National Model: Understanding Socio-Economic Change and Policy Alternatives," System Dynamics Group Working Paper D–2248–2, Alfred P. Sloan School of Management, M.I.T., Cambridge, 1975 and Nathaniel J. Mass, "Economic Cycles: An Analysis of Underlying Causes" (Wright-Allen Press, Cambridge, 1975).

structure of parameters and relationships, does it really make no difference whether a Democratic or Republican administration guides fiscal policy? Few observers would believe it.

A related issue is the selection of specifications and parameters of relationships in systems dynamics models. The approach apparently followed for the most part has been to base these on judgments of individuals involved in the processes being modeled, on a priori reasoning, and on rough approximations to historical proportions, trends, or other magnitudes. Statistical estimation appears to have been utilized little if at all, and verification of the possible reliability of individual equations seems to have for the most part been ignored or carried out in minimal fashion. Validation of properties appears to have consisted mainly of comparing the cyclical characteristics of dynamic solutions with those of the economy and not of subjecting the models to a battery of predictive tests. Without results from such tests, how can policymakers have any assurance that simulation studies with systems dynamics, national economy models provide reliable guidance for the possible course of future events or for the selection of policy options?

On another note, the treatment of stochastic shocks, can it really be true, for instance, that the simultaneous existence of high unemployment and inflation in the United States in 1974–5 can be blamed on an inevitable Kondratieff cycle? Or is a more reasonable explanation one that places heavy reliance on OPEC pricing, foreign harvest failures, and the conduct of wage-price controls policy in 1971–73? Stated more generally, is it plausible that operations of the economy can be modeled solely in deterministic fashion or must continuing stochastic influences be taken into account? Isn't this especially necessary if relationships are presumed to be non-linear and dynamic paths depend on gaps between desired and actual states? Notwithstanding that random shocks may be damped and gradually disappear, can't the transients be sufficiently large and last sufficiently long that they have significant impacts on the path of the economy? Unequivocally, the answers are yes.

As presently constituted by Forrester, Mass, Meadows, and others, systems dynamics models of economic growth may have a role in providing broad perspectives and insights into economic development processes. They can be useful to Federal government policymakers primarily as a tool for exploring different scenarios in the use of policy tools and for examining the potential consequences of changes in the characteristics and operation of the economy. But, the techniques need refinement, especially in the area of specification and estimation of structure and parameters. Validation and predictive tests of the models, too, are crucial and without them, systems dynamics simulations should mainly be viewed as interesting and suggestive academic exercises.

Econometric Models

Econometric models structurally bear a strong resemblance to present systems dynamics models but differ in a number of important respects. While both strive to mirror behavior of economic agents, formulations in most large-scale econometric models begin with sets of theoretical propositions and principles (such as profit and utility maximization goals for producers and households, respectively) and derive

equation specifications therefrom. Allowance is made, as in systems dynamic models, for desired states or targets and for gradual adjustment to disequilibrium positions. Parameters of equations largely are estimated by "fitting" historical data, but selected coefficients are chosen or constrained on a priori grounds. Bayesian principles, using notions of distribution of variances and covariances of parameters are beginning to be employed in estimation of some large-scale econometric models, too. Such priors have been specified by model builders based both on their own intuitions and knowledge and on information obtained from participants in the processes being modeled.

Therefore, the primary difference in specification of the structure of models between present systems dynamics and econometric approaches is the greater reliance on deductive theory rather than inductive observation by the econometric technique. Which degree of reliance is superior depends on the accuracy with which the specifications accord with actual behavior, a question which can only be answered by empirical observation, predictive tests, and conformity with meeting other validation criteria. Econometricians have begun to apply systems dynamic techniques in specification and estimation of selected sectors of their models, which is a partial indication that a combination of the two methods may be superior to either alternative.[17] Given the relative infancy of the systems dynamics approach, it is difficult to predict the precise nature of the combination.

However, the final amalgam probably will lie closer to an econometric formulation in at least several other features. First, the model would picture the world in a combination deterministic and stochastic framework. Second, provision would be made for exogenous influences, which impinge from outside the system and are not controllable from within. Third, the structure of the economy would not be presumed to be fixed but rather to be subject to rapid and evolving shifts. Such changes are attributable to a variety of forces, including the impacts of innovation and technology, revisions in tastes and preferences, relative availabilities of natural resources, and so forth.

Unfortunately, the most widely used econometric models of the U.S. economy are oriented toward short-run analyses and prediction and, for the purpose of long-run forecasts, make inadequate allowance for structural change. They take little account, for example, of shifting demographic patterns, evolving technology, or relative resource availabilities. Most of these models have quarterly time frames and their parameters are estimated using data for approximately the 20 year period following the Korean War. In general, the shorter the sample period, the more tenuous are long-range predictions. Moreover, the further the forecast from the sample period, the larger is the potential error band. For these reasons, whatever the prediction errors of the models in short-run, or near-term forecasting, they are likely to be larger for long-run projections.

It is possible to specify and construct econometric models that can serve the dual purpose of short- and long-run economic analysis and prediction. Efforts in this direction have begun, partially in response to growing scientific, policymaker, and public recognition that policy decisions dealing with short-run issues (for example, an energy crisis)

[17] See, for instance James Tobin and Walter Dolde, "Wealth, Liquidity and Consumption," in *Consumer Spending and Monetary Policy: The Linkages*, Federal Reserve Bank of Boston, Conference Series No. 5 (1971), pp. 99–147. These methods also are being used by William C. Brainard, Gary Fromm, and James Tobin in the construction of a flow-of-funds model of the U.S. economy.

may have important and costly long-run implications which should be taken into account.[18] Also, there has been rising interest in tracking and predicting the consequences of evolving changes in the size and distribution of the population, resource availabilities, the goods-services consumption mix, the integration of the world economy, and so forth. Skeptics of large-scale econometric models point to sometimes poor forecasting performance and other deficiencies of such systems. Occasionally there have been large prediction errors, but there also have been notable successes. The subject of how such models can be improved further (it might be noted that average prediction errors have decreased over the past decade) is too broad to be taken up here. But, given time and adequate resources, more structurally realistic and accurate models can be built incorporating the best elements of statistical, systems dynamics, and econometric techniques.

Growth Projections

The Sample, Methodological Characteristics, and Assumptions

Forecasts of U.S. economic performance over the 1975–85 interval were solicited from respondents to the American Statistical Association—National Bureau of Economic Research short-run forecasting survey and a variety of other sources. Twenty-two forecasts were obtained; many of those solicited indicated that they prepared only short-run projections or that their long-run predictions were fragmentary and incomplete. While the sample is small and includes only 22 forecasts, it is felt to be representative of the range and character of the "best" and currently most widely used U.S. economic projections for the next decade.

The forecasts are not strictly comparable to each other because they were prepared at different times (from mid 1975 through fall 1976). The projections made most recently have advantages of later initial conditions and the availability of officially reviewed national income and product account statistics. Given opportunities for modifications, this might cause some differences in the earlier predictions but, judging from the long-term projections made by some respondents in 1975 and then revised in 1976, should not alter them greatly. Large changes in predictions could occur, of course, if a forecaster drastically modifies his views on the future course of the economy.

It might also be noted that a number of forecasts in the sample are not completely independent, but are partially based directly or indirectly on projections of others, including the widely available services of Chase Econometrics Associates, Data Resources, Inc., and Wharton Econometric Forecasting Associates. Where known, such dependence has been indicated in the summary of selected characteristics of the forecasts. (See table 5) All the respondents utilize a variety and combination of methods in preparing their projections, but rely to a greater degree on some chosen technique. Of the 22 forecasts, six place primary emphasis on econometric models and seven use such models as an important input to their analyses. The remaining nine forecasts rely more heavily on reduced form and judgment methods.

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[18] A new macro-econometric model for studying the medium-term growth path of the U.S. economy recently was completed by Bert G. Hickman and Robert M. Coen, An Annual Growth Model of the U.S. Economy (North-Holland, Amsterdam, 1976). Forecasts from this model are not yet available and it requires further testing.

TABLE 5.—SUMMARY OF SELECTED CHARACTERISTICS OF LONG-TERM ECONOMIC FORECASTS

Respondent	Primary method	Time frame	Scale [1]	Disaggregation of production [2]	Endogenous, financial—real interaction [3]
Chase	Model	Quarterly	Large	Limited	Medium
DRI	do	do	Very large	Medium (recursive)	Strong.
Wharton	do	Annual	do	High	Medium.
SSG	do	do	do	do	Weak.
NPA	Model assisted [4]	do	Large	Limited	Medium.
GE	Model	Quarterly	Medium	Medium	Do.
INFORUM	Model	Annual	Very large	High	Weak.
NYSE	Judgment	10-year	Very small		
BDC	Analysis based on models	5-yr	Medium	Limited	Do.
BF	Model assisted	5-yr	Small	do	Do.
A	Analysis	Annual		Limited	Do.
B	Model assisted [5]	do		High	Weak.
C	Analysis	5-yr		Limited	Do.
D	Judgment	5-yr		do	None.
E	do	2, 3-yr		do	Do.
F	Model assisted	5-yr	Medium	do	Do.
G	Judgment	Annual		do	Do.
H	Analysis	5-yr		do	Weak.
I	Model assisted [6]	Annual		None	Do.
J	Judgment	do		Limited	Do.
K	do	do		do	Do.
L	Model assisted	do		Medium	Do.

[1] Based on number of equations: very small equals 9 or less; small equals 10 to 49; medium equals 50 to 119; large equals 120 to 199; very large equals 200 or more.
[2] Based on sector detail: limited equals 2 to 5 sectors; medium equals 6 to 20 sectors; high equals 21 or more sectors.
[3] Based on qualitative judgments on pervasiveness of financial variables in real sector equations or impacts and real variables in financial sector equations of impacts.
[4] Chase.
[5] DRI.
[6] DRI, Wharton, Michigan.

SOURCES

Chase—Michael K. Evans, "Long-Term Macroeconomic Forecast" (Chase Econometric Associates, Inc. June 1976).
DRI—The Data Resources U.S. Long-Term Bulletin. "The Economic Outlook 1975–90." Summer 1976.
Wharton—Wharton Econometric Forecasting Associates, Inc. "Wharton Annual and Industry Forecasting Model," July 20, 1976.
SSG—Economic Policy Board Special Study Group, unpublished materials partially based on "The Structure of the U.S. Economy in 1980 and 1985," BLS Bulletin 1831 (U.S. Department of Labor, 1975).
NPA—Henry Townsend, Timothy Sivia, Mark Kenda II, David Fay and Jessica Townsend, "The Next Ten Years," report No. 76–N–2 (National Planning Association, September 1976).
GE—"Economic Prospects: 1975–85" (General Electric, March 1975) and Supplementary materials.
INFORUM—Interindustry Forecasting Project of University of Maryland.
NYSE—"The Capital Needs and Savings Potential of the U.S. Economy; Projections Through 1985" (the New York Stock Exchange, September 1974).
BDC—Barry Bosworth, James S. Duesenberry, and Andrew S. Carron, "Capital Needs in the Seventies" (Brooking Institution 1975).
BF—Benjamin M. Friedman, "Financing the Next Years of Fixed Investment," Sloan Management Review, Vol. 16 No. 3, Spring 1975, pp. 51–74.
The remaining respondents include 7 large industrial enterprises, 3 financial organizations and 1 academic institution

The basic time unit of the forecasts varies from a ten-year span for one of them to quarterly projections for three others. Eleven forecasts are done year-by-year (annually) and the remaining seven are 3–5 year predictions. The models utilized range from very large with hundreds of equations to small with nine or fewer equations. As a rule, disaggregation of production is "limited" to "medium" and interactions of the financial and real (production) sectors is of weak to medium strength. Overall, the variety of characteristics of the approaches to long-term forecasting is more notable for its diversity than its uniformity. A priori, those that contain greater structural detail and information should be more useful. Whether these also are more accurate predictions of aggregates, such as overall real GNP growth rates cannot be determined at this time because of the extremely short history of use of models for long-term forecasting.

However, some general patterns emerge on the assumptions made by different respondents. (See table 6.) Assumptions about fiscal and monetary policy are especially important because of their potentially

strong impact on growth paths. For those forecasters that provided the information, it was found that most anticipated only modest increases in federal spending and no real (constant dollar) tax reduction. Therefore, with economic growth, federal deficits are expected to decline from their recent high levels and, in some cases turn into surpluses. Monetary policy is seen as continuing in a tight to accommodating vein. Where inflation and unemployment are assumed exogenously, both are predicted to fall from present rates and approximate or be below historical averages of the past decade during the first half of the 1980's.

TABLE 6.—ASSUMPTIONS UNDERLYING LONG-TERM ECONOMIC FORECASTS

Respondent	Federal Government expenditures	Tax policy	Federal budget position	Monetary policy	Other assumptions
Chase	No change in spending programs.	No change in tax laws.	Continuing high Federal deficits.	Tight monetary policy with double digit inflation in 1978.	1. Recession in 1978–79 with unemployment rate rising to more than 10 percent. 2. Negative net exports in nominal terms in 1980–85.
DRI	Tightening of spending; real purchases growing less than potential output; real transfer payments grow faster than output.	Personal tax cuts, holding tax to about 11½ percent of income; effective corporate tax rates gradually decline with investment tax credit assumed permanent at current 10 percent value.	Moderately high deficit but declining in 1980–85.	If stop-go monetary policy is avoided, short-term interest rates would stabilize at a rate near 6½ percent.	Dampening of State and local spending because of higher costs of borrowing.
Wharton (stimulative scenario).	Increase in nondefense purchases of $15,000,000,000 by 1979 and maintained at this level throughout 1979–85 with peak increase of 250,000 Federal employees by 1978, declining slowly for remainder of period.	Investment tax credit maintained at 10 percent. Social insurance tax rate programed as law now stands for 1975–85 with rise to 12.3 percent in combined employee-employer rate in 1981; earnings base to rise at rate of $1,200 per year.	Full employment and greater tax revenues from higher level of economic activity lead to turnaround from deficit position in 1976–80 to surplus in 1981–85.	1. More stimulative policy beginning in 1977. 2. Reduction of discount rate and increase in nonborrowed reserves.	1. Corrected version of Census series No. 2 used in estimates of population and labor force growth. 2. World trade activity assumed to grow at average annual rate of 5.2 percent during 1978–85.
SSG	1. No new programs. 2. Growth in transfer payments to reflect real income maintenance. 3. Grants-in-aid increase less rapidly than recent past (3.5 percent real growth).	1. 1975 personal tax cut ($8,000,000,000) made permanent. 2. $6,000,000,000 personal tax cut in 1976. 3. $6,000,000,000 per year in personal tax cuts 1977–82 to maintain real tax effect. 4. Permanent 10- to 11-percent investment tax credit. 5. Corporate profit tax rate lowered to 45 percent. 6. Depreciations allowances increased by 5 percent. 7. Gas tax increase to 7 cents per gallon from 4 cents.	Declining deficit to $8,900,000,000, 1985.	Accommodating, stable.	1. Full employment target of 4-percent unemployment rate by 1985. 2. Inflation down to 4 percent per annum, 1980–85. 3. Average 3-percent productivity gain through 1985.
NPA	1. Real rise in defense expenditures of 2 percent per year; nominal outlays rise 8.6 percent per year. 2. Nondefense purchases rise at 2.2 percent real and 9 percent nominal rates, 1975–86. 3. Transfers increase at 9.5 percent rate and grants-in-aid at 8.6 percent rate, 1975–86.	No significant change in income or corporate taxes; small increase in Social Security taxes.	Deficit of $31,000,000,000 in 1979; $21,000,000,000 in 1986.	Moderate to accommodating monetary policies.	Constant prices for imported petroleum; modest inflation in other import prices.
GE	1. Expenditures increase at 10.2 percent rate, 1976–85.	1. Reduction in corporate income tax rates from 48 to 43 per-	Deficits: 1976, $65,000,000,000; 1977, $39,000,000,000; 1978,	1. Emphasis on containing inflation with "real" growth of	1. Lower growth in labor force. 2. Lower productivity gains.

	2. Defense outlays gain slightly through 1985. 3. Transfers rise to 63 percent of outlays, 1977–80, and to 66 percent by 1985.[1]	cent, 1977. 2. Permanent 12-percent investment tax credit, 1977. 3. Special tax treatment for ailing industries (e.g., railroads and public utilities).	$27,000,000,000; 1979–85, $12-000,000,000 to $22,000,000,000.	M1 comparable to late 1950's to early 1960's: 1973–80, 0.7 percent; 1980–85, 1.3 percent. 2. Nominal growth around 9 percent per year.	3. Continuing high unemployment rate.
INFORUM	1. Constant real defense expenditures. 2. Modest increases in nondefense spending.				1. Continuing high inflation. 2. Steady reduction in unemployment rate to level of 5.6 percent in 1985.
NYSE	Projects deficit only	Assumes no change	$3,500,000,000; annual deficit (based on average deficit, 1954–63).	No mention	
BDC	1. No net new Federal programs. 2. Expenditures grow 8.7 percent per year. 3. Grants-in-aid grow 6.2 percent per year for continuation of existing programs. 4. Transfer payments increase 10.9 percent per year for funding existing laws.	No change; revenues rise 11.1 percent per year (higher inflation rate would increase revenue growth; tax elasticity equals 1.2).	$82,000,000,000 initial surplus, 1980; used to offset State and local financing gap of $25,000-000,000 and increase Federal purchases $44,000,000,000. Net surplus equals $13,000,000,000. (Note: Offsets not included in 1st column.)	Because of fiscal restraint (surplus), easier monetary policy, lower interest rates than 1974.	
BF	1. Only modest new spending initiatives. 2. Constant expenditure share of GNP (excluding transfers). 3. Transfers grow faster than GNP. 4. Expansion in real terms consistent with real GNP growth.	Tax reductions to offset inflation impact on revenues so that budget is balanced.	Balance on average during 1977–81.	Relatively tight; less rapid creation of bank reserves than in last 10 years.	1. Real GNP growth of 3½ to 4 percent annually. 2. Inflation rate of 5 percent yearly.
A	Expenditures to decline slightly as percent of GNP.	Contracyclical tax measures	Declining deficit	Contracyclical, achieving stabilization of interest rates.	Unemployment rate to drop to 5 percent level in 1980's.
B	1. Goods and services purchases in real terms will grow less than real GNP. 2. Transfer payments will increase faster.				Assumes 2 mild growth cycles with cyclical lows in 1978 and 1982.
C	Real outlays rise at 4 percent, 1970–85; further shift goods and services to transfers.	Small net increase in total tax burden with a decline in Federal individual rates but increases in corporate and State and local taxes.	Balance at near full employment	Mildly restrictive to neutral	1. Real GNP trend at 3¼ percent annually. 2. Inflation rate of 3¼ percent in 1980's.
D					1. Annual population growth less than 1 percent. 2. Labor force will increase at higher rate because of changing age mix but will slow down in 1980's.
E					Labor force growth between 1 and 2 percent; declining average workweek; productivity growth about 2 percent per year.
F					Decreasing unemployment rate, approaching 5 percent by 1985.

See footnotes at end of table.

TABLE 6—ASSUMPTIONS UNDERLYING LONG-TERM FORCASTER—Continued

Respondent	Federal Government expenditures	Tax policy	Federal budget position	Monetary policy	Other assumptions
G	Federal spending focused on consumption sector at expense of production side of economy.		Lower Federal deficits, but no surplus.		1. Moderate recession for 1978–79 period. 2. Continuing rise in inflation rate, approaching double-digit level in 1978. 3. Slow decline in unemployment rate with floor of 6½ percent.
H			Deficits to continue		Unemployment rate will average more than 5 percent but with long-term trend toward full employment.
I				Up to 1978 monetary policy is accommodating to rapid recovery. Federal Reserve sticks to money growth targets and as inflation accelerates liquidity is squeezed.	1. Moderate global recession in 1978–79. 2. Unemployment rate will decline but persist at higher than socially acceptable levels. 3. Peak inflation rate at 8 percent in 1978; falling to 4.5 percent in 1981.
J					1. Persisting high unemployment during 1976–80, with rate of 7.5 percent in 1980. 2. Inflation rate declines to 5 percent by 1980.
K					Concurs with BLS projection of 3.6 to 3.7 percent growth during 1980–85 period.
L	1. Fiscal policy geared toward gradually reducing unemployment and increasing utilization of productive capacity. 2. Health insurance program instituted by 1979; expenditures starting at $9,000,000,000 and rising to $27,000,000,000 by 1985; partly financed by payroll taxes. 3. Social security benefits will rise about 5 percent annually over next decade. 4. Federal Government will start to absorb local government's welfare costs with expenditures starting at around $4,000,000,000 in 1980 and rising to $20,000,000,000 by 1985.	1. Personal tax cut of $8,000,000,000 in 1978. 2. Other changes in personal and corporate taxes assumed to provide offsetting gains and losses in Treasury receipts. 3. Combined social security tax rate will rise to 12.1 percent in 1978, 12.7 percent in 1979, and 13.3 percent in 1981. Taxable income base will rise to $28,500 by 1985.	Deficits will continue at high level through 1982 and then decline sharply.	Will be aimed at avoiding excessive expansion of money supply but will accommodate economic growth.	

[1] All Federal outlays other than purchases of goods and services (includes transfers to persons, interest payments, grants to State and local governments, and subsidies to Government enterprises).

Output, Inflation, and Income

Most of the forecasters see a generally favorable picture for output, inflation, and income over the next ten years. (See Table 7.) With a recovery from the 1974–75 recession, the median forecast for the annual compound growth rate for real GNP is 4.8 percent for 1975–80 and 3.5 percent for 1980–85.[19] These rates exceed those of most five- and ten-year post recession intervals during the post-World-War II period (cf. Table 1 above for partial comparison). The range of real GNP forecasts for 1975–80 is from 2.6 to 6.5 percent annual rates. Those at the low end, notably Chase, G, and I, anticipate a recession in 1977–78 or 1978–79, which lowers real GNP during those years and 1980 and their respective 1975–80 growth rates. In all these cases the recession is attributed to reactions to a tight monetary policy which the Federal Reserve is expected to undertake during 1977 in an attempt to lower the rate of inflation.

[19] These and other compound growth rates herein are computed between magnitudes of variables at the terminal years. They are not averages over the path.

TABLE 7.—LONG TERM ECONOMIC PROJECTIONS: OUTPUT, INFLATION, AND INCOME—COMPOUND ANNUAL RATES OF CHANGE

[In percent]

Respondent	Real GNP			Inflation (GNP deflator)			Real capital formation (fixed investment)			Real disposable income			Real net exports total real trade [1]		
	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85	1976–85	1976–80	1980–85
Median forecast	4.1	4.8	3.5	5.3	5.7	5.0	5.6	7.4	4.2	3.7	4.2	3.3	6.4	7.3	5.1
Chase	3.9	3.6	4.1	5.6	5.8	5.5	6.1	6.1	6.0	3.5	3 4	3.7	8.7	8.8	8.6
DRI	4.0	4.9	3.2	4.5	5.0	4.0	5.2	7.1	3.2	4.0	4.7	3.2	8.3	9.8	7.0
Wharton [2]	3.6	4.4	2.9	4.9	5.7	4.0	5.6	7.5	3.8	3.3	3.6	3.0	2.4	2.7	2.1
SSG	5.0	6.5	3.6	4.8	5 0	4.4	6.8	9.5	4.2	4.8	6.0	3.6	3.8	5.3	2.8
NPA [3]	4.0	4.5	3.5	5.8	5.9	5.6	5.4	7.1	4.1	3.8	4.1	3.6	4.4	5.7	3.3
GE	4.1	4.6	3.6	6.8	7.5	6.1	6.0	7.3	4.8	3.8	4.4	3.2			
INFORUM	3.2	4.0	2.4	9.5	8.7	10.3	5.2	8.2	2.3	3.1	3.7	2.5			
A	4.2	5.0	3.4	5.3	5.6	5.1	5.6	7.5	3.8	3.9	4.3	3.6			
B [4]	3.9	4.9	3.2	5.7	5.9	5.5	5.0	6.9	2.9	3.7	4.2	3.1	16.8	5.4	6.3
C	4.2	5.0	3.4	4.0	4.4	3.5				4.3	5.2	3.3			
D	4.7	5.4	4.1				6.2	8.3	4.3						
E	4.5	5.5	3.5							4.2	4.5	3.8			
F	4.2	4.9	3.6	5.1	5.7	4.5									
G		2.6			7.2										
H	3.5–3.8									3.5–3.8					
I		3.3			[5] 5.7						3.4				
J [6]		4.0			5.7						[6] 9.3				
K	[7] 4.0	4.3	3.7	5.5	6.0	5.0	5.5	6.5	4.5	3.5	[7] 3.2	3.8			
L	4.5	4.9	4.1	5.0	5.4	4.4	7.2	8.4	6.0	3.5	4.1	3.0	9.9	9.4	10.3

See footnotes on p. 23.

Respondent	Real exports			Real imports			Government real expenditures: Federal Government			Government real expenditures: State and local		
	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85
Median forecast	[8] 4.3	4.3	4.3	6.3	7.7	5.1	[8] 1.8	1.9	1.6	[8] 3.4	3.3	3.5
Chase	2.7	1.8	3.7	3.7	4.6	2.8	.9	1.7	.1	3.9	2.8	4.9
DRI	5.3	6.4	4.2	7.4	9.0	5.8	2.0	1.8	2.2	3.2	3.0	3.4
Wharton [3]	5.3	4.6	6.0	7.7	10.8	4.7	2.6	3.7	1.5	2.6	2.6	2.7
SSG	6.4	7.6	5.1	8.0	10.3	5.6	2.3	2.1	2.5	4.0	4.2	3.9
NPA	3.2	2.6	3.8	5.4	6.6	4.5	2.0	2.5	1.5	3.7	3.5	3.9
GE							1.4	1.2	1.6	3.7	3.9	3.6
INFORUM	2.4	1.4	3.5	4.1	4.5	3.8	1.2	1.2	1.3	2.0	2.2	1.8
A							−1.3	−2.5	0	.1	−.4	.7
B [4]	4.2	4.1,	4.3	5.8	7.5	3.9	2.2	2.9	1.3	3.9	4.3	3.5
C												
D							2.4	2.5	2.3	5.4	5.6	5.3
E												
F												
G												
H												
I												
J [6]												
K							2.1	2.0	2.2	3.0	2.7	3.3
L	6.1	6.0	6.1	6.8	7.9	5.7	2.1	1.8	2.4	4.0	3.5	4.4

[1] Average ratios of levels.
[2] Stimulative.
[3] 1975–86; 1975–80; 1980–86.
[4] 1975–86; 1975–81; 1981–86; except real GNP and inflation which are 1975–86, 1975–80, 1980–86, and ratios of real net exports to total trade which are for single years: 1975, 1981, 1986.
[5] 1976–81.
[6] 1976–80.
[7] Nominal rate.
[8] Average of 2 periods medians.

A moderate fall in the rate of increase of the overall GNP deflator is expected by all forecasters, with performance improving gradually over the next decade. Still, inflation rates remain above five percent; only four respondents predict that inflation may drop below five percent. By way of comparison, during 1966–75 the GNP deflator increased at a compound annual rate of 5.8 percent. The essential message in the predictions is that given fiscal policies of mild expenditure growth and tax cuts, accommodating money supply growth, and an absence of external shocks, inflation stays below double-digit levels and does not accelerate.

These are favorable conditions for real capital formation and is reflected in the anticipated scenario of the forecasts. During 1975–80, real fixed capital spending grows on average (across the forecasts) about 50 percent faster than real total product. This faster rise is attributable to needs to compensate for low rates of capacity expansion during the past decade, continuing adjustment to higher energy prices, and outlays for pollution control facilities. In some forecasts, much of the catch-up is completed by the early 1980's and thereafter, real investment and real GNP grow at nearly the same rates. In other forecasts, especially those with recessions in 1977–79, the process, and higher rates of investment than output, continues in the 1980's. (Questions of capital shortage are discussed in a following section.)

The relative rise in investment is accompanied by a relative fall in consumption. The latter is brought about by a slower rate of increase of real disposable income than real GNP and is a consequence of a progressive income tax structure and tax cut policies. The elasticity of tax revenues with respect to nominal GNP is greater than unity (taxes rise more than proportionately to product or income), so that unless tax rates are reduced so as fully to offset inflation, rates of growth of real disposable income and consumption expenditures fall relative to real pre-tax income growth. This is not necessarily undesirable if income growth itself depends on pursuit of such policies.

One of the more difficult areas to forecast is the foreign trade sector, where developments depend on the evolution of both the domestic and world economies. U.S. experts are anticipated to rise in the years ahead but imports, under stimulus of recovery from the 1974–75 recession and growing demands for foreign oil, spurt even faster. Therefore, the highly favorable 1975 trade balance is eroded until 1980 under most forecasts. The proportion of real net exports to total trade averages nearly 6½ percent for the ten-year period 1976–85, but faster rising imports reduce the ratio from 7.3 percent in 1976–80 to 5.1 percent for 1981–85. Only one respondent predicts a higher ratio of net exports to total trade in the latter portion of the ten-year interval.

The last six columns of table 7 list rates of growth of real Federal and state and local expenditures. Federal outlays grow far more slowly than real GNP under the assumption by all respondents that the government will pursue conservative fiscal policies. The rate of growth of state and local outlays, too, is slowed from that of the last decade due to voter resistance to increased taxation and bond issues, active restraint on expenditures so as to preserve credit worthiness and potential bankruptcy difficulties such as those confronting New York City and other municipalities, and lesser needs as total and school-age population growth slows.

Most of the forecasts utilize the medium projections of the U.S. Bureau of the Census to extrapolate population growth which, for all age groups combined, is anticipated to increase at one percent per annum over the next decade. The population above 15 years of age is anticipated to rise somewhat faster than the total due to falling birth and death rates. Therefore, the potential labor force grows more rapidly than population and also is swelled by the continuing rise in female labor force participation. During the 1975–80 period, the labor force is augmented, too, by a decrease in the number of discouraged workers who, with a decline in unemployment, again seek employment. These forces are reflected in the median predictions reported in table 8, which show labor force compound growth of 1.9 percent from 1975–80 and 1.3 percent from 1980–85. The lower rate in the latter five years is attributable to slower real growth and tapering of increases in female and discouraged worker participation rates.

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TABLE 8.—LONG-TERM ECONOMIC PROJECTIONS: EMPLOYMENT, PRODUCTIVITY, AND FINANCE
COMPOUND ANNUAL RATES OF CHANGE

Respondent	Population (percent)			Labor force (percent)			Unemployment rate [1] (percent)			Employment (percent)		
	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85	1976–85	1976–80	1981–85	1975–85	1975–80	1980–85
Median forecast	1.0	1.0	1.0	1.5	1.9	1.3	5.7	6.5	5.0	2.0	2.5	1.5
Chase [2]	1.3	1.5	1.0	1.7	2.0	1.5	7.3	8.4	6.2	2.1	1.8	2.3
DRI	1.0	0.9	1.0	1.6	1.9	1.5	5.4	5.8	5.0	2.1	2.8	1.5
Wharton [3]	1.3	1.5	1.0	1.6	1.9	1.4	5.3	5.6	4.6	1.9	2.7	1.2
SSG	1.0	0.9	1.0	1.5	1.8	1.2	5.3	6.4	4.3	2.2	2.8	1.5
NPA	0.9	1.0	0.9	1.6	1.8	1.4	[4] 5.6	6.3	[4] 5.0	1.6	2.4	1.5
GE	0.8	0.8	0.8	1.5	1.8	1.2	[5] 6.5	7.1	[5] 5.9	1.7	2.0	1.4
INFORUM	1.0	0.9	1.0	1.3	1.4	1.1	6.1	6.6	5.7	1.7	1.9	1.5
A	1.0	1.0	1.0	1.5	1.9	1.1	5.8	6.5	5.0	1.9	2.5	1.3
B [6]	0.9	0.9	1.0	1.5	2.0	0.9	5.9	6.7	[7] 5.0	1.9	2.6	0.9
C	1.0	1.0	1.0	1.5						1.9		
D	1.0	1.0	1.0	1.6	1.7	1.4						
E				1.5	2.0	1.0						
F [8]	1.0	1.0	1.0	1.7	2.0	1.4	6.5	7.4	5.6	2.1	2.5	1.6
G												
H				1.4	1.7	1.0	5.0+	5.0+	[9] 5.0+			
I												
J												
K		0.9										
L	1.0	0.9	1.0	1.7	1.9	1.5	5.7	6.5	4.9	2.1	2.6	1.7

Respondent	Productivity [10] (percent)			Money supply (percent)			Aaa bond rate [1] (percent)			Average government surplus or deficit [11] (in billions of dollars)					
										Federal (D)			State and local (S)		
	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85	1976–85	1976–80	1981–85	1976–85	1976–80	1981–85	1976–85	1976–80	1981–85
Median forecast	2.3	2.3	2.1	[12] 7.0	7.6	6.6	8.3	8.8	8.0	−31.9	−37.9	−25.0	[12] 14.0	14.6	13.3
Chase [2]	1.8	1.8	1.8	6.7	6.4	7.1	8.6	8.8	8.4	−86.3	−88.0	−84.7	15.7	16.2	15.2
DRI	1.9	2.2	1.7	6.6	7.2	6.0	8.1	8.5	7.7	−31.9	−37.9	−25.9	8.6	10.0	7.2
Wharton [3]	1.6	1.5	1.7	7.9	9.7	6.2	7.4	8.3	6.6	−12.5	−31.7	+6.7	17.5	18.3	16.7
SSG	2.9	3.6	2.1							−20.0	−23.5	−16.4	10.4	7.7	13.2
NPA	[4] 2.2	2.2	[4] 2.1	7.0	7.2	6.9	9.0	9.4	8.7	−55.0	−70 4	−40.0	17.7	20.4	15.0
GE	2.3	2.5	2.1	8.4	9.4	7.5	[5] 9.8	10.2	[5] 9.5	[5] −27.3	−33.1	[5] −21.5			
INFORUM	1.4	1.6	1.2												
A	2.3	2.4	2.1				8.2	8.4	8.0	−24.2	−32.4	−16.0			
B [6]	2.3	2.4	2.1												
C	2.4														
D															
E															
F [8]	2.1	2.3	2.0												
G															
H															
I															
J								8.9							
K	2.3	2.4	2.2	7.0	8.0	6.0	8.3	8.8	7.8	−33.0	−40.0	−25.0			
L	2.3	2.3	2.4							−48.8	−62.0	−35.6	9.9	14.0	5.8

[1] Average of annual rates of all years in each period (not rate of change).
[2] Population 16 years and more.
[3] Stimulative scenario; population 15 years and more.
[4] End year of forecast is 1986.
[5] Estimated from incomplete statistics.
[6] Middle and end years of forecast are 1981 and 1986.
[7] Drops to 5 percent by 1985.
[8] Unemployment rates are 1975–85, 1975–80, 1980–85.
[9] Declining during this period.
[10] Real GNP per employee (derived).
[11] Averages of annual surplus or deficit: (D) Deficit unless otherwise specified; (S) Surplus.
[12] Average of 2 periods medians.
[13] Surplus.

Note: Where figures not supplied, information unavailable.

Average projections for unemployment rates over these intervals are 6.5 and 5.0 percent, respectively. Chase has the most pessimistic outlook and their unemployment rate averages 8.4 percent, which in large measure is due to prediction of a 1977–78 recession. Respondents F and H also predict a recession at that time, but their unemployment rate forecasts are lower. All respondents forsee that the unemployment picture will improve significantly over the second half of the 1975–85 decade, despite declines in rates of increase of real growth rates. Employment growth rates, of course, mirror those of labor force, unemployment, and output. They are more rapid in 1975–80 than 1980–85. When they are more rapid (less rapid) than labor force growth, unemployment falls (rises).

The declines in unemployment and growth in employment are accompanied in most of the projections by a recovery in productivity, as measured by real GNP per employee or per worker-hour. The slowdown in productivity growth in the early 1970's has been traced to very slow growth in capital-labor ratios and to entrance into the work force of unusually large numbers of young and inexperienced workers, which tended to offset productivity enhancing factors such as increased education.[20] As the demographic mix changes and the young work force gains experience, the effects should be to increase productivity growth rates.

Other factors which held productivity growth down to near-zero levels (setting aside cyclical influences, real GNP per hour of labor grew at only about one percent between 1970–75) were the energy crisis (which made a portion of the capital stock economically obsolete), environmental regulations which forced production cutbacks and modifications of procedures and equipment and, possibly, the temporary effects of the wage-price controls program. Adjustments to these factors, while still not complete, should become less important in the years ahead.

High rates of investment relative to employment growth should provide a strong stimulus to productivity in the last half of the 1970's. Changes in the composition of the workforce will help, too. The median forecast for the rate of growth of real GNP per employee (which is slightly greater but approximately the same as per worker hour) is 2.3 percent for 1975–80 and 2.1 percent for 1980–85. While these are below the 2.7 percent productivity growth rates of 1965–75, they are far better than recent experience and contribute greatly to the revival of rapid real output growth.

The feasibility of achieving the high rates of investment necessary for this productivity growth depends in part on questions of finance. Declining Federal deficits and decreases in state and local borrowing will reduce demands on money markets and thereby ease private access. Most respondents expect the money supply to grow at a rate of 2–3 percent less than the rate of increase of nominal GNP, so some financial tightness is envisaged.[21] Long-term interest rates are anticipated to remain around 8–9 percent, which is consistent with a forecast inflation rate of about 5–6 percent and a real rate of return of about 3 percent.

[20] Unpublished materials prepared for the Interagency Task Force on U.S. Productivity Growth, September 1976.

[21] The median forecast for nominal GNP growth can be approximated by the sum of the rates for real GNP and inflation plus their cross-products. That is, e.g. from table 7, for 1975–85, $4.1+5.3+(4.1)(5.3)/100=9.6$ percent.

Capital Requirements

Returns to capital and investment have figured prominently in the debate of the last few years on the possibilities of a capital shortage.[22] The controversy has raged between those who deny that a shortage could ever exist and those who believe serious gaps between desired and actual capacity may occur. The former group states that market forces will lead to adjustment of product, labor, and capital goods prices so that demand and supply for capital will be in equilibrium. If capital goods prices rise relative to other prices, then rates of return fall. Returns to savings then also would fall. The latter group admits that this may be true, but that the equilibrium might occur at levels of savings, investment, capital-labor ratios, and capacities below those deemed socially desirable. If the target is a high rate of growth of output, and unutilized capacity and labor force growth are low, this requires, assuming productivity advance cannot dramatically be spurred, a high rate of growth of investment.

Investment requirements over the next decade are predicted to be high not only for the reason of a social target of lowering unemployment rates, but also because of continuing energy reconversion and augmentation needs, and pollution abatement and environmental goals. Most of the studies surveyed here show a significantly higher proportion of GNP devoted to investment in 1975–85 than in 1966–75. (See Table 9.). Despite substantial differences in these predicted proportions, in other GNP expenditure shares, and in nominal and real GNP growth rates, there appears to be a consensus on a number of points:

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[22] Issues in this section are examined in greater detail in Gary Fromm, "Investment Requirements and Financing: 1975–85," National Bureau of Economic Research, October 1975.

TABLE 9.—LONG-TERM ECONOMIC PROJECTIONS: CAPITAL REQUIREMENTS

[Percent]

	History	Chase			DRI			Wharton [1]		
	1966–75	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85	1975–85	1975–80	1980–85
GNP growth rate	8.1	9.7	9.6	9.9	8.9	10.4	7.3	8.7	10.3	7.0
Inflation growth rate	5.8	5.6	5.8	5.5	4.5	5.0	4.0	4.9	5.7	4.0
Real GNP growth rate	2.2	3.9	3.6	4.1	4.0	4.9	3.2	3.6	4.4	2.9
Unemployment rate [2]	5.0	7.3	8.4	6.2	5.4	5.8	5.0	5.1	5.6	4.6
High-grade (Aaa) corporate [2] bond rate, new issues	7.1	8.6	8.3	8.4	8.1	8.5	7.7	7.4	8.3	6.6
	1966–75	1976–85	1976–80	1981–85	1976–85	1976–80	1981–85	1976–85	1976–80	1981–85
As percent of GNP:										
Gross private domestic investment	15.1	16.7	14.8	17.9	15.8	15.7	15.8	17.1	16.3	17.6
Nonresidential	10.2	11.9	10.8	12.6	10.7	10.5	10.8	12.4	11.2	13.2
Inventory	.7	1.1	.3	1.6	.9	1.1	.8	.8	1.0	.7
Residential	4.2	3.7	3.7	3.6	4.2	4.1	4.3	3.9	4.1	3.8
Total savings	15.1	16.7	14.8	17.9	15.8	15.7	15.8	17.1	16.3	17.6
Business	11.0	13.3	12.6	13.7	11.4	11.2	11.5	13.7	13.2	14.0
Personal	4.9	5.4	5.3	5.5	5.1	5.5	4.8	3.5	3.9	3.1
Government	−1.0	−2.7	−3.6	−2.2	−.9	−1.3	−.6	.2	−.6	.8
Federal	−1.4	−3.3	−4.4	−2.6	−1.2	−1.8	−.8	−.5	−1.5	.2
State and local	.5	.6	.8	.5	.3	.5	.2	.7	.9	.5
Other	.2	.7	.5	.9	.2	.4	.1	−.3	−.3	−.3
Investment less savings										
GNP expenditures (percent distribution):										
Gross private domestic investment	15.1	16.7	14.8	17.9	15.8	15.7	15.8	17.1	16.3	17.6
Personal consumption	62.6	61.9	63.7	60.7	62.7	62.8	62.7	61.9	62.6	61.4
Net exports	.5	0	.2	−.1	.5	.8	.3	−.2	−.1	−.2
Government purchases	21.9	1.4	21.3	21.5	21.0	20.7	21.2	21.2	21.2	21.2

	SSG			NPA,	GE,	NYSE,	BDC,	BF,
	1975–85	1975–80	1980–85	1975–86	1975–85	1974–85	1973–80	1977–81
GNP growth rate	10.0	11.8	8.2	10.0	11.1	8.5	9.2	8.9
Inflation growth rate	4.8	5.0	4.4	5.8	6.8	5.0	4.7	5.0
Real GNP growth rate	5.0	6.5	3.6	4.0	4.1	3.6	4.3	3.7
Unemployment rate [2]	5.3	6.4	4.3	[4] 5.6	[4] 6.5	----	[4] 4.3	----
High-grade (Aaa) corporate bond rate, new issues [2]	----	----	----	----	[4] 9.8	----	[4] 7.5	----
	1976–85	1976–80	1981–85	1974–85	1976–85	1974–85	1973–80	1977–81
As percent of GNP:								
Gross private domestic investment	15.4	15.4	15.4	16.1	14.9	16.4	15.6	15.8
Nonresidential	11.2	11.1	11.2	11.2	10.7	[5] 9.4	10.9	11.5
Inventory	.9	1.1	.8	.7	.5	[6] 3.1	.7	.8
Residential	3.3	3.2	3.4	4.2	3.7	4.0	4.0	3.5
Total savings	15.4	15.4	15.4	16.1	14.9	15.0	15.6	15.8
Business	11.2	11.3	11.1	12.4	10.9	10.6	10.6	10.8
Personal	4.7	5.0	4.4	4.7	5.8	4.0	4.6	4.9
Government	−.4	−.8	−.1	−.14	−1.4	.3	.2	−.1
Federal	−.7	−1.1	−.5	−1.9	−1.1	−.2	.3	0
State and local	.4	.4	.4	.5	−.3	.5	−.1	−.1
Other [3]	−.1	−.1	0	.4	−.4	0	.1	.2
Investment less savings	----	----	----	----	----	1.4	----	----
GNP by expenditures: [7]								
Gross private domestic investment	15.4	15.4	15.4	16.1	14.9	16.4	15.6	15.8
Personal consumption	62.5	63.0	62.2	62.3	62.0	----	60.6	61.8
Net exports	.3	.3	.3	−.1	−.1	----	.2	−.2
Government purchases	21.8	21.3	22.2	21.7	23.2	----	22.4	22.6

See footnotes on p. 32.

TABLE 9—LONG-TERM ECONOMIC PROJECTIONS: CAPITAL REQUIREMENTS—Continued

[Percent]

	L		
	1975-85	1975-80	1980-85
GNP growth rate	9.6	10.5	8.7
Inflation growth rate	5.0	5.4	4.4
Real GNP growth rate	4.5	4.9	4.1
Unemployment rate [2]	5.7	6.5	4.9
High-grade (Aaa) corporate bond rate, new issues [2]			
	1976-85	1976-80	1981-85
As percent of GNP:			
Gross private domestic investment	16.3	15.4	16.9
Nonresidential	11.1	10.2	11.6
Inventory	1.0	1.0	1.0
Residential	4.2	4.2	4.3
Total savings	16.3	15.4	16.9
Business	12.4	12.0	12.7
Personal	5.2	5.5	5.0
Government	—1.5	—2.3	—.9
Federal	—1.8	—3.0	—1.1
State and local	.4	.7	.2
Other [3]	.1	.3	.1
Investment less savings			
GNP expenditures (percent distribution):			
Gross private domestic investment	16.3	15.4	16.9
Personal consumption	61.8	62.8	61.3
Net exports	.4	.4	.4
Government purchases	21.4	21.4	21.4

[1] Stimulative scenario.
[2] Periods are 1976–85, 1976–80, 1981–5 for Chase, DRI, Wharton and SSG; 1976–85 for GE.
[3] Statistical discrepancy plus capital grants received by the United States less net foreign investment.
[4] Estimated from incomplete statistics.
[5] Includes plant and equipment only.
[6] Includes inventories and business other nonresidential investment.
[7] BDC model excludes 1.2 percent unallocated resources.

Note.—Results estimated when figures in sources are incomplete or presented in other forms. Detail may not add to totals due to rounding; — equals not available or not applicable.

Source: History, Survey of Current Business, January 1976, July 1976.

1. The economy has the ability to generate sufficient savings to meet investment needs of the next decade, including increased outlays for energy conversion, pollution abatement, and capacity expansion.

2. To make this possible, Federal expenditures should be restrained so that current high deficits are reduced and government saving is raised.

3. Individual income tax cuts will be needed to offset a progressive tax rate schedule and limit reductions in real consumer incomes arising from inflation.

4. Monetary policy should be accommodating and should not foster but seek to prevent episodes of highly restrictive credit availability.

5. The principal problem is financing increased investment in an inflationary setting when nonfinancial corporate business exposure to working capital needs are swollen, depreciation falls short of replacement costs, growth in retained earnings is insufficient to fund much higher capital outlays, and relative rates of return are too low and risks too high to attract much greater equity funding. Because of this financial situation, a majority of the analyses provide or recommend reduction in corporate taxes so as to raise rates of return and augment financial cash flow.

The last conclusion holds notwithstanding a stock market recovery and improvement in conditions of equity financing during the past year, recent surges in corporate margins and profits, and the 1976 tax reform act which extended the 10 percent investment credit. These provide greater internal cash flow and equity capital but, given high investment demands, greater resort to borrowing will be required and debt/equity ratios are predicted to continue to rise. For some companies and sectors these already are at high levels, and both borrowers and investors are exposed to substantial risks of default. If investment can be accomplished only by further weakening of financial structure, many companies may decide to forego capacity expansion even in the face of strong demands for their outputs. Obviously, the situation does not apply equally to all industries. It is most severe for capital intensive sectors whose capital structure already is highly leveraged, whose rates of return are below average, and whose prices or returns (profit rates) are subject to a high degree of government regulation. Transportation, electric utilities, steel, paper, and a few other industries may be particularly hard pressed by finances, demand, and environmental and safety requirements.

Growth Strategies and Policy Alternatives

Whether policy actions should be undertaken to alleviate investment problems confronted by capital intensive industries is a question that has aroused strong emotions among those opposed to lowering tax burdens of corporate business, others who are as concerned about the adequacy of profit returns and the continuing viability of the free enterprise system, and yet others opposed to high growth rates and further environmental encroachment. There is no easy answer because any attempt at solution depends greatly on balancing the preferences and

needs of diverse interests. Somehow it is necessary to achieve a national consensus on the relative importance of different goals, or at least a weak preference ordering among them, so that policy choices can be made which come closer to maximizing social welfare.

It is true that some apparent conflicts between achievement of different goals can be eased, if not eliminated, by use of a wide range of policy instruments which offset or deter undesired effects. For instance, while high growth may entail greater natural resource use, marginal resource requirements can be reduced by greater emphasis on conservation and recycling, shifts toward relatively less scarce resources, and channeling growth into activities that are less natural resource intensive. To some extent markets naturally, through supply and demand forces and the price mechanism, channel use of resources toward those that are relatively more plentiful and less costly. But, social and private costs and preferences may differ and therefore various forms of intervention may be needed to achieve more socially desired results. This sometimes can be accomplished in part via utilizing or reinforcing market forces through strengthening incentives toward movement in socially preferred directions. Excises and subsidies long have been employed by government for this purpose.

The first step, of course, is to determine the social goals and targets. This set most likely will include some goals that are complementary and others which are competitive or substitutes. For example, lowering the proportion of the population with incomes below poverty levels is compatible with raising economic growth rates, but may be accompanied, unless otherwise offset, by stimulation of inflation. Other things being equal, the greater the concern about inflation, the less the emphasis that can be given to growth and income redistribution. There are situations in which higher growth and redistribution lead to lower inflation (for example, when there is a large pool of foreign migrant workers that augment the labor supply on an as-needed basis), but these are far less common than the reverse.

The establishment of national priorities and tradeoff rates between them is critical because this conditions the set of policies which can best be used for their achievement. Relative preferences for different goals lead to relative emphases on alternative policy strategies and tools. For any set of objectives, there is a socially most efficient set of policies which has the highest expectation of achieving the goals. Social efficiency is defined in terms of maximization of a social welfare function wherein weight is given to the utility or disutility of policy instruments as well as to the resource and other consequences of policy actions. While it may not be simple to place values on such elements as the degree of intervention or loss of freedom of choice associated with given policies (such as wage and price controls), this should not be viewed as impossible. A variety of techniques, including referenda, surveys, and experiments can be employed to help ascertain social preferences in these and other areas which involve tradeoffs between psychic and material returns.

Unfortunately, little research has been conducted on defining and measuring social welfare functions. In the economic growth field, economists often have simply used an objective of maximization of the discounted value of real (constant dollar) personal consumption outlays. This might be sufficient if all other net positive effects were proportional to this criterion, but this is unlikely to be true in reality.

Growth prescriptions which employ this objective as the basis for choice between policy alternatives are likely to be biased in the direction of quantity of growth without proper regard to its "quality" in terms of distributional, environmental, freedom-of-choice, and other consequences.

Nevertheless, some useful information can be obtained when such simplistic objective functions are utilized together with models of the economy to explore policies to attain feasible production-possibility growth paths in the neighborhood of this or a similar criterion. Simulations of this nature with econometric models of the United States were run for examinations of cyclical stabilization policies about a decade ago and during the past few years, but they have not yet been done in an economic growth context.[23] These stabilization studies and multiplier results from long-run simulations may, however, have a few significant implications for growth policies.[24]

First, after allowing for a delay of 6–9 months, stimulative monetary policy can have sizable impacts on real aggregate output. In some models there is a decay in these effects after three or four years, while in others they continue to grow. Tax and expenditure (fiscal) policy is more effective in the initial year but, again decays in impacts are found after a few years. For all stimulative policies of reasonable magnitude, very little impetus is given to inflation in the first year or two. But, the long-run cumulative impact on price levels is high because period-to-period changes in prices remain positive throughout the 10-year spans over which the simulations were conducted.

The principal message from these simulations may well be that policies which are oriented primarily toward stimulation of demand, which may be necessary, may at the same time be insufficient to generate adequate supply. That is, there is a counterpart to Say's law. Just as supply may not beget its own demand, so may demand not beget its own supply. Growth policies that are to be effective probably must be designed to work on both sides of the demand-supply equation.

Demand stimulus will, to some extent, create investment incentives to augment capacity. Still, these may not be sufficiently strong to sustain continuing capacity growth, especially in capital intensive sectors. Similarly, greater job opportunities may induce workers to seek additional training and education but, again, of inadequate magnitude or types to match growth in labor requirements. Research and development, too, may not be carried out with sufficient intensity on a broad scale and in high risk areas so as to promote strong productivity advance. Government regulations designed to counter recession maladies and monopoly abuses may at the same time restrict competition, thereby fueling inflation and inhibiting growth. Other inefficiencies in the U.S. economic system abound, and whatever rate of growth

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[23] These simulations utilized more complex objective functions which admitted additional arguments (variables) such as investment and government expenditures, inflation, unemployment rates, capacity utilization, and foreign trade balances. See G. Fromm and P. Taubman, "Policy Simulations With an Econometric Model" (Brookings, Washington, D.C., 1968), J. H. Kalchbrenner and P. A. Tinsley, "On the Use of Feedback Control in the Design of Aggregate Monetary Policy," American Economic Review, vol. 66, No. 2, May 1976, pp. 349–55, and Albert Ando and Carl Palash, "Some Stabilization Problems of 1971–75, With an Application of Optimal Control Algorithms," in Michael Intriligator (ed.), Frontiers of Quantitative Economics, vol. III (North-Holland, Amsterdam, 1976).

[24] Multiplier paths for various models, including DRI and Wharton, may be found in G. Fromm and L. R. Klein, "The NBER/NSF Model Comparison Seminar: An Analysis of Results," "Annals of Economic and Social Measurement," vol. 5, No. 1, Winter 1976, pp. 1–28.

is to be sought, government actions to reduce them could aid productivity and cut resource waste, desirable goals in their own right.

In formulating growth strategies and examining policy alternatives it also is important to pay heed to international considerations. The world economy is becoming increasingly integrated, and U.S. dependence on foreign demand and supply, as indicated by the ratios of exports and imports to GNP, has doubled over the past twenty years. These trends are likely to continue as foreign nations become larger purchasers of U.S. foodstuffs and manufactures and U.S. import requirements for raw materials and petroleum rise. Therefore, it is necessary to consider the effect of U.S. growth policies on the economies of other countries and the feedback reactions this may generate.

Evidence from simulations with the LINK model suggests that an additional one percentage point of growth of the U.S. economy in 1976 might produce increases in world trade of 0.2 percent in 1976 and 0.5 percent in 1977.[25] While the impacts of this higher world trade on gross domestic product (GNP) of various countries would individually be small (the largest being that for Canada which would have a GNP 0.4 percent higher in 1977), the total income effect on other nations could easily exceed the amount of initial growth stimulus from the U.S. This, in turn, would lead to rises in demand for U.S. exports, thereby raising U.S. incomes further.

On the other side of the coin, economic and political developments may have either beneficial or harmful long-term effects on the U.S. economy. For instance, formation and operation of effective cartels—OPEC is an obvious example—can dramatically raise crude material costs and drastically alter the set of efficient production and growth possibilities. Customs unions, free trade areas, and other multinational forms of economic coopertaion may either stimulate or retard demand for U.S. exports in the directly affected countries or in other world markets. Instability in international finance payments mechanisms could inhibit both capital and trade flows, thereby limiting foreign income growth and impinging on domestic finance and product. To the degree that U.S. policy aids or abets such developments, this should be taken into account in the formulation of growth strategies.

Conclusion

About a decade ago there were great expectations that the 1970's would be years of strong economic expansion and of rapid advance in U.S. living standards. The record to date surely has been disappointing. The next five years should prove far more satisfying as most forecasters predict a moderately strong recovery from the 1974–75 recession and downward tapering of unemployment and inflation rates. Thereafter, growth is expected to be more modest and declines in unemployment and inflation less rapid.

There are a number of major uncertainties in this scenario, including possible errors in management of fiscal and monetary policy, a potential capital shortage brought about by poor financial structure of capital intensive industries, and the effects of shocks from cartels,

[25] These calculations were performed under the direction of Lawrence R. Klein at the University of Pennsylvania and are summarized in the 1976 Economic Report of the President, p. 135.

world food shortages, military or political upheavals, or other unanticipated sources. A successful growth outcome will depend upon pursuit of a galaxy of policies designed to affect both demand and supply and to maintain proper balance between them.

The tools available to formulate such policies and to accurately project growth under different strategies still are highly imperfect and in need of refinement. Combinations of econometric models and systems dynamic approaches would appear to provide the greatest potential for fulfilling growth forecasting and analysis needs. Given the great benefits which a stronger analytical capability of growth strategies would provide, government support for such research should receive high priority. Research on social welfare functions should also be accorded strong emphasis in order that better guides to national preferences for tradeoffs between goals such as growth, income distribution, environmental quality and so forth, would be available for the formulation and choice of public policies.

UNDERSTANDING THE CHANGING BASIS FOR ECONOMIC GROWTH IN THE UNITED STATES

By NATHANIEL J. MASS *and* JAY W. FORRESTER*

SUMMARY

In 1974 and 1975 the U.S. economy encountered a deeper recession than had occured since World War II. With the recession came a high rate of inflation, faltering growth in real output, and unusually severe unemployment. These difficulties all measure an increase in economic instability, as suggested vividly by the title of a recent report issued by the Conference Board, *The Widening Cycle.*

The greater instability in the economy appears to be caused by two principal modes of economic behavior whose existence is not widely recognized and whose causes are only poorly understood: the Kondratieff cycle, or long wave, and the life cycle of economic development. The Kondratieff cycle is a long-term, approximately fifty-year, fluctuation in prices, interest rates, employment, and production of capital goods. The significance of the long-wave phenomenon to public policies lies in the fact that, if the long wave is a real recurring element of the national economy, then the Great Depression of the 1930's probably represented a typical low point of such a cycle. In the 1970's we are now about fifty years past the Great Depression, and signs are that the growth process is again faltering. The question arises, is the long wave of underlying structural origin, and is a severe economic downturn arising from the long wave likely or avoidable?

The second mode of economic behavior that is receiving insufficient attention is the life cycle of economic development. The life cycle spans the period of approximately two hundred years duration, during which population and industrialization grow and are eventually restrained by a range of physical, environmental, and social limits. Such limits include rising energy and food prices and growing social complexity. Evidence suggests that the United States may be entering a transition period during which growth begins to slow, eventually leading to some form of future equilibrium.

Whereas economic stabilization policy is today predicated chiefly on prevailing theories of the short-term business cycle, current economic developments probably arise from the interaction of both short- and long-term modes of economic behavior. This paper therefore attempts to describe some of the principal long-term forces that will influence the national economy over the next 10 to 30 years, and suggests some of their implications for public attitudes and national

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policy regarding economic growth. The preliminary recommendations deriving from the paper are summarized below:

(1) *Recognizing the multiple modes of economic behavior.*—Present economic difficulties may arise from a confluence of three modes of economic behavior: the business cycle, the long wave, and the life cycle of economic development. Misattribution of all symptoms of difficulty to the short-term business cycle can lead to adoption of ineffective government policies. Proposed Congressional actions and legislation should be evaluated from the standpoint of which modes of behavior they are designed to address, and how any proposed policy will affect causes of the several very different modes.

(2) *Understanding the nature of the recent recession.*—The greater severity of the recent recession may be an indication of the top of a long-term capital cycle, leading to an excess of capital plant. Evidence for such an emerging capital excess is seen in the decline of capacity utilization rates, high unemployment rates of college-educated persons, growing debt burden on corporations, faltering growth in housing construction and machine tools, appearance of excess office space in major urban areas, and other symptoms.

(3) *Expanding the time frame of stabilization policy.*—The long wave of some 45 to 60 years duration may exert a far greater disturbing force on the economy than the short-term business cycle. In order to address this long-term mode, the scope and time horizon of economic stabilization policy must be broadened from the present outlook of a few months to several decades.

(4) *Understanding the causes of the business cycle.*—The short-term business cycle appears to be caused primarily by interactions between inventories and employment. Capital investment does not seem to be a fundamental contributing cause of the business cycle. Seeing the business cycle in terms of inventories and employment implies that present monetary policies designed to stabilize the business cycle by influencing the incentives for capital investment may exert only low leverage for control. Alternative bases for stabilization policy consistent with causes of the business cycle must be sought.

(5) *Policies for dealing with the long wave.*—Appropriate policies for controlling the long-wave mode may differ quite substantially from presently-advocated economic policies, or even from policies to stabilize the short-term business cycle. To the extent that the long-wave downturn is a consequence of overinvestment in physical capital, investment tax credits or rapid expansion of money supply by the Federal Reserve may provide little stimulus for investment. Alternatively, the opposite policy of restraining monetary growth may lower inflation with little contractionary effect on output and employment. There may also be a possibility of cushioning the downturn by encouraging the diversion of resources from capital-excess areas arising from the long wave to areas of capital shortage, such as energy production, created by the life cycle of economic development. Such policies as described above are tentative proposals, but they need to be considered if we are to manage the economy through the changes emerging from the long wave.

(6) *Coexistence of high inflation and unemployment.*—Unemployment and inflation may coexist if inflation is caused by increase in the money supply, unemployment is caused by reaching a peak in the long wave, and money supply has little effect on the long-wave fluctuation. Simultaneous high inflation and unemployment may also stem from a downswing of the long wave superimposed on life-cycle pressures limiting growth, especially if money supply is expanded in an attempt to offset the recessionary forces.

(7) *Limitations of the Phillips Curve as a guide to policy.*—Much of economic policy is predicated on the Phillips-Curve concept which implies the existence of a stable tradeoff between unemployment and inflation. However, the Phillips-Curve relationship has probably been misinterpreted as a general relationship between all sources of inflation and all sources of unemployment. Our work thus far indicates that the balance of inflation and unemployment in the economy depends in a complex way on the many modes of behavior in the economy as well as on the governmental policies being followed. This implies that the Phillips-Curve concept is not a reliable indicator for public policy. The Phillips Curve needs to be broadened into a deeper understanding of the relationships between inflation and unemployment deriving from the interactions between the various modes of economic behavior.

(8) *Policies for the life cycle.*—Policies for adapting to the transition region of the life cycle will need to be developed in concert with stabilization policies for the business cycle and long wave. As suggested earlier, use of conventional monetary and fiscal policy may be more inflationary than stimulative in an era of growth restraints set by physical and social forces. New policies will be needed in areas such as energy, materials, agriculture, and water resources.

(9) *Increased emphasis on policy rather than decision-making.*—A policy is an enduring rationale or decision rule that describes how a decision will be made under any possible set of circumstances. A policy can endure until the economic system is better understood and an improved policy has been determined. By contrast, decisions continuously change and are the action of the moment occurring as a consequence of applying the established policy to the changing conditions of the economic system. Too much attention is given to current government decisions and not enough to the background policies that govern the decisions. A clear statement of economic policy, or general decision-making criteria, is lacking in most governmental agencies. More emphasis should be given to underlying policies guiding government decision-making, and less emphasis to isolated decisions.

(10) *Increased research into the dynamics of the national economy.*—The policy directions summarized here represent only a starting point in developing improved management of economic behavior. Much additional work is needed to refine the analysis of the business cycle, long wave, and life cycle; to organize additional evidence for the resulting theories of economic behavior; to test the effects of alternative policies; and to disseminate results to a broad public audience. Economic problems confronting

the nation are of sufficient magnitude to merit a large-scale commitment of government R & D funding to understand them better. Such work should be conducted by multiple groups using different methodologies in order to foster competition between groups and increase the likelihood of success. It is important, however, that the methodologies used by capable of dealing with long-term behavior; multiple modes of change; and feed-back interaction between economic, social, psychological, and demographic forces. With new efforts we can hope to achieve greater public understanding of prospects for economic growth and more effective government policies for responding to social and economic difficulties.

I. Time Horizons for Analyzing Economic Growth

In 1974 and 1975 the U.S. economy encountered a deeper recession than had occurred since World War II. With the recession came a high rate of inflation, faltering growth in real output, and unusually severe unemployment. These difficulties all measure an increase in economic instability, as suggested vividly by the title of a recent report issued by the Conference Board, The Widening Cycle.

In response to increased economic instability government and the public have emphasized the same monetary and fiscal policies employed in preceding recessions—expansion of money supply and government deficit. However, despite apparent effectiveness in the past, such policies today seem unable to restore economic health and achieve a favorable balance between inflation and unemployment. At the same time, opinion is growing that the recent recession is significantly different in character from previous recessions.

Our recent investigations suggest two principal modes of behavior in the national economy as contributing to present difficulties—the Kondratieff cycle, or long wave, and the life cycle of economic development. The existence of these two modes is not widely recognized and their causes are only poorly understood. The Kondratieff cycle is a long-term, approximately fifty-year, fluctuation in prices, interest rates, employment, and production of capital goods. This long-wave phenomenon was originally identified in statistical studies conducted in the 1920's by the Russian economist Nikolai Kondratieff.[1] It has recently begun to receive renewed attention in newspaper articles, financial publications, government agencies, academic literature, and even the popular press.[2] Present interest in the long wave derives from a recognition that, if the long wave is a real recurring element of the national economy, then the Great Depression of the 1930's probably represented a typical low point of such a cycle. Since the 1930's the country has experienced relatively vigorous and sustained growth of economic activity. But we are presently about fifty years past the Great Depression, and signs are that the growth process is again faltering. The question arises, is the long wave of underlying structural origin, and is a severe economic downturn arising from the long wave likely or avoidable?

[1] See Kondratieff (1935) for the English translation of Kondratieff's work.

[2] See, for example, Rostow (1975a); p. 12; Bank Credit Analyst (May 1973 and December 1974); Levy-Pascal (1975); Rostow (1975b); Forrester (1975a); and Shuman and Roseanu (1972).

The second mode of economic behavior that is receiving insufficient attention is the life cycle of economic development. The life cycle spans the period, of approximately two hundred years duration, during which population and industrialization grow and are eventually restrained by a range of physical, environmental, and social limits. Such limits include rising energy and food prices and growing social complexity. Evidence suggests that the United States may be entering a transition period during which growth begins to slow, eventually leading to some form of future equilibrium.[3]

This paper attempts to clarify the causes of, and interaction among, three principal modes of economic behavior: the short-term business cycle, the long wave, and the life cycle of economic development. Whereas economic stabilization policy is today predicated chiefly on prevailing theories of the short-term business cycle, current economic developments probably arise from the interaction of both short- and long-term modes of economic behavior. If the identity of the separate modes is not recognized, symptoms arising from one part of the system may be misinterpreted and applied to policy control points in some entirely different part of the system. Policy is then ineffective because it is based on an improper diagnosis of symptoms that led to adoption of the policy. These observations indicate an urgent need to expand understanding of economic behavior and stabilization policies beyond current focus on the short-term business cycle. This paper describes some principal long-term forces that will influence the national economy over the next 10 to 30 years, and suggests implications for national policy regarding economic growth.

II. System Dynamics Methodology as a Tool for Analyzing Growth Issues

The viewpoints developed in this paper regarding economic behavior and economic policy stem from the "system dynamics" approach for analyzing social systems. This section gives a brief description of system dynamics, and outlines the main features of the methodology that suit it for analyzing long-run economic growth issues.[4]

II.A *Description of System Dynamics*

System dynamics is a way of combining all available information, including written description, numerical data, and personal experience, with computer simulation to yield a better understanding of social systems. The system dynamics approach starts by constructing a model of how the various actors in a social system go about making decisions. Such a model consists of a set of cause-and-effect statements describing how different circumstances, pressures, and motivations influence the decision-maker and lead to action. The approach draws heavily on descriptive information and observation about the information sources available to the decision-maker, and the way information is converted into action. A system dynamics model is designed to

[3] For more detailed discussion of these issues, see Forrester (1971); Meadows et al. (1972); Forrester (1975b); and Madden (1975).

[4] Readers familiar with system dynamics or primarily interested in the behavioral and policy aspects of the paper may wish to skip directly to section III.

capture the intangible or non-measured influences on real-life decision-making, such as attitudes, values, and expectations, in addition to incorporating measured variables and numerical data.

A well-constructed system dynamics model is a captive replica of the actual system it is designed to portray. The model can be simulated on a computer to see the behavior over time that arises from the interaction of policies in different parts of the system. In other words, the computer simulates, or plays the roles of, the many participants in the system to see how they interact with one another to produce changing patterns of behavior. In operation, a system dynamics model should reproduce internally the same modes of behavior seen in the actual social system and should exhibit the same kinds of observed problems, such as inflation, instability, and high unemployment. As the model behavior is explored in detail, new insights emerge about causes of behavior. Moreover, once the model is exhibiting the behavior and difficulties seen in the real system, it can be altered readily to incorporate new or proposed policies for governing the system. By simulating the model with the new policies, and comparing the resulting behavior to the performance of the system with the old policies, the effectiveness of alternative policies can be assessed.

II.B. *System Dynamics Studies of Social Systems*

System dynamics has been under development at MIT and elsewhere since 1956. The approach has been applied to studying behavior of a range of social systems, spanning from corporate to urban to global behavior.[5] These earlier studies provide the basis for discussion in Section III of the life cycle of economic development. Most recently, the MIT System Dynamics Group, under direction of the authors, has been working on developing a comprehensive model of social and economic change in the United States. The System Dynamics National Model is composed of seven basic sectors: production, financial, household, demographic, labor, government, and foreign trade. These sectors describe the major determinants of production, consumption, investment, employment, prices, government policy, balance of payments, and other activities and indices of economic performance. Sectors of the Model are interconnected by flows of information, people, money, goods, services, and orders.

The National Model is far more comprehensive than earlier system dynamics models. The Model is highly detailed, and contains a range of internal spanning from short-term inventory-management and price-setting policies to capital investment policies and long-term demographic and environmental forces. By encompassing a diversity of short-term and long-term forces, the National Model will deal with long-range issues of economic growth, resources, energy, population, and capital investment, as well as with shorter-term dynamics of the business cycle and economic stabilization policies. The detailed structure and ability to integrate long-term and short-term behavior are necessary for comprehensive policies analysis and for describing alternative futures.[6]

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[5] See Forrester (1961); Forrester (1969); Mass (1974); Schroeder, Sweeney, and Alfeld (1975); Forrester (1971); Meadows et al. (1972); Meadows and Meadows (1973); and Meadows et al. (1974).

[6] See Forrester and Mass (1975) for a fuller description of the National Model.

Most individual sectors of the National Model have been formulated. Individual sectors are now being tested and improved. Assembly of separate sectors into the full National Model is underway. Assembly of a first version of the National Model will take about two years to allow thorough testing of the Model. During assembly, Model assumptions and behavior will be made available to a range of individuals in academic institutions, the private sector, and government for criticisms that can be a basis for improvement. But even at the present time, partial assemblies of the National Model are exhibiting behavior that raises important questions about national policy and prospects for economic growth. The results reported in Section III of this paper regarding the causes of the business cycle and the long wave summarize these preliminary findings.

II.C. *Characteristics of System Dynamics*

As a prelude to Section III on growth issues, this section outlines the main characteristics of the system dynamics methodolgy that make it especially useful for analyzing economic growth issues and integrating short-run and long-run behavior. The discussion draws on examples from the National Model to illustrate major points:

(1) The system dynamics approach focuses on representing adaptive behavior of decision-makers, and requires no assumptions about equilibrium or market clearing. Economic growth and economic fluctuation are inherently disequilibrium modes of behavior. Preliminary computer simulations of the production sector of the National Model show, for example, that both the business cycle and the long wave may be caused by typical corporate-management policies regarding labor acquisition and capital investment as they are influenced by inventories, order backlogs, and growth expectations within producing sectors.

(2) A system dynamics model distinguishes sharply between, and interrelates, stock and flow variables. The model conserves all flows of money, orders, goods, people, and financial assets in the sense that the effects of rates of flow in changing system levels (stock variables) are all represented explicitly. For example, in the National Model, shipment of capital goods depletes the output inventory of the capital-producing sector and adds to the factor inventories of capital equipment in receiving sectors. In an economic system, stock variables such as inventories and backlogs decouple rates of flow such as production and shipments. Representation of intervening stock variables, and their impact on decision-making, is essential for portraying changes in economic activity that occur when rates of flow are out of equilibrium. In turn, such portrayal of disequilibrium behavior is necessary for understanding the processes of economic growth and instability.[7]

(3) A system dynamics model integrates supply and demand considerations. For example, the National Model portrays both price adjustments arising from imbalances between supply and

[7] See Mass (1976a) for further discussion.

demand as well as quantity adjustments—for example, production-rate changes induced by inadequate inventories or high order backlogs. Stock and flow measures of supply and demand—for example, resource stocks, inventories, and order backlogs on the one hand, and production and consumption rates on the other—are both incorporated comprehensively. Market clearing occurs through both price and availability. Thus, for example, demand for a particular commodity or material may be discouraged by high price or by low availability, as manifested by shortages and a long delivery delay. In contrast to the integration of supply and demand in the National Model, many economic models focus primarily on supply variables [8] or on demand variables.[9] This deficiency of economic models is noted by Carl Madden who states, ". . . we must concern ourselves with supply as well as demand. We must look at long-term relationships of population, food, raw materials, energy, invention and innovation." [10]

(4) The structure of a system dynamics model is derived from observation of real-life decision-making processes, not inferred from numerical data. For example, the production sector of the National Model contains a rich description of how capital investment decisions in a typical corporation are made on the basis of influences such as average shipment rate, actual and desired output inventory, actual and desired backlog of orders for output, delivery delay for capital equipment, price of capital equipment, capital equipment on order, price of output, long-term and short-term growth expectations, money balances, interest rates, and return on investment. In addition to containing a rich policy structure, a system dynamics model can also include relationships which lie outside the range of observed data (such as effects of resource depletion on energy costs), but which may become influential in future modes of behavior.

(5) A system dynamics model can interrelate economic, social, and psychological variables. Any statement or hypothesis which can be expressed clearly in English about the relationship between variables in a system can be incorporated in a system dynamics model. Various hypotheses about social and attitudinal variables can thus be included as part of the policy structure of a system dynamics model and examined in terms of their behavioral implications. For example, the National Model will contain such social variables as the effect of attitudes toward public support of individuals on the evolution of welfare and social security payments, influences on birth rates and desired family size, pressures for environmental control, and attitudes toward retirement age. Such issues are important due to the tight coupling that exists between social, demographic, and economic variables. Such interrelationship is seen, for example, in the growing concerns about the future of the Social Security system and the effects of large Social Security obligations on economic growth rates as population growth slows and average retirement age declines.

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[8] See, for example, Solow (1970).
[9] See, for example, Samuelson (1939), which fostered the modern theories of the "multiplier" and "accelerator."
[10] Madden (1975), p. 11.

(6) A system dynamics model can incorporate any nonlinear relationships that exist in reality. Nonlinearities impose physical restraints on action and are influential in causing shifts from one mode of economic behavior to another. Such shifts, manifested by rising energy prices or increasing economic instability, can occur rapidly and must be understood if economic policy is to be effective in anticipating future behavior of the economy and formulating appropriate responses.

(7) A system dynamics model can be used to understand the qualitative behavior of a system, that is, to discern the various possible modes of behavior and how they can be influenced by changes in policies. Also, a system dynamics model can be used to anticipate shifts in the dominant mode of behavior of the socio-economic system. Understanding how the different modes of behavior arise is critical in diagnosing symptoms of difficulty and developing appropriate policies. For example, if the economy is in recession due to long-term forces, the policies appropriate to a normal business-cycle downturn may be ineffective or even counterproductive (see Sections III and IV).

(8) A system dynamics model can be used to formulate policy guidelines or rules for improving system behavior. Very often, decision-makers in Washington will rely on a forecast of future behavior as a basis for making a decision at the present time. Such a process has two major difficulties. First, in a complex social system such as the economy, the presence of random disturbances tends to preclude forecasting the state of the system far enough ahead to allow time for effective action.[11] However, while forecasting the precise condition of the economy at some point in the future may be infeasible, it will generally be possible to forecast and understand the general mode of economic behavior. Second, the emphasis on isolated decision-making at the present time detracts from a broader understanding of how policy should be made in general. How should we be reacting to high inflation or to unemployment? A broader focus in government on policymaking is essential as the complexity and interconnectedness of the national system grow, and as the fundamental mode of behavior of the system undergoes change (see Section IV for elaboration).

From the above description of system dynamics, differences in structure and use can be identified between system dynamics models and the econometric models used widely in economic analysis. Several of these differences are summarized briefly below. In particular, compared with a system dynamics model,

(1) The structure of an econometric model is derived largely from interpreting economic theory in the light of available data, rather than from observation of real decision processes;

(2) An econometric model tends to focus more on equilibrium concepts and behavior, as distinguished from adaptive disequilibrium behavior;

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[11] Appendix F of Forrester (1961) emphasizes the importance of designing improved policies for guiding decisions, rather than attempting prediction. In Appendix K the presence of random disturbances is shown to preclude accurate forecasting of the future condition of a social system very far ahead. On the other hand, if two policies are compared, the policy that is less vulnerable to random disturbances is always less vulnerable regardless of the particular random sequence that impinges on the system.

(3) An econometric model does not adhere as strictly to the principle of conservation of flows;

(4) Dynamic behavior in an econometric model arises more from exogenous inputs and distributed-lag formulations than from explicit processes of integration embedded in interacting stocks and flows;

(5) The structure of an econometric model is limited to measurable concepts for which numerical data exist rather than allowing full incorporation of descriptive information;

(6) An econometric model which is derived from time-series data can only incorporate relationships between variables that lie within the range of observed data and which reflect the past mode of system behavior;

(7) An econometric model tends more to incorporate linear approximations of relationships between variables rather than giving general nonlinear formulations;

(8) An econometric model is used primarily for short-term point forecasting rather than for development of general policy criteria or for understanding possible future modes of behavior;

(9) The process of constructing an econometric model tends more to emphasize numerical precision in parameter estimates for short-term forecasting purposes rather than identifying structures that underlie long-term change.

III. Simultaneous Modes of Economic Behavior

This section describes three primary modes of economic behavior: the business cycle, the long wave, and the life cycle of economic development. In each case, a mode of behavior is described, an explanation of behavior is given, and broad implications of behavior mode are discussed. Section IV subsequently integrates these viewpoints into a set of policy directions for dealing with interacting modes of behavior.

III.A. Business Cycle

III.A.1. BACKGROUND

The business cycle is the predominant focus of discussions of economic instability in the business press and economic literature. The business cycle, as noted by Arthur Burns, is a recurring fluctuation, of average four-year periodicity, in employment, output, inventories, prices, and capital investment.[12] Numerous theories of the business cycle have been advanced. Most of these theories, including, for example, the theories of Paul Samuelson, John Hicks, and James Duesenberry, attribute business-cycle fluctuations to fluctuations in fixed capital investment. Such theories have been accepted widely, and they underlie economic stabilization policies, including monetary policy, which focus on regulating investment opportunities as a means for controlling the overall cycle. From the perspective of this paper, the focus of economic policy on the business cycle, and the underlying capital-investment theory of business fluctuations, has two primary defects. First of all, attributing all economic behavior to the business cycle ignores the contribution to behavior of the longer-term modes

[12] Burns (1969), p. 14.

such as the long wave and life cycle of economic development. Such incorrect attribution of behavior to underlying causes may lead to inappropriate policy actions. Second, simulation studies with the System Dynamics National Model suggest that capital investment policies are not fundamentally involved in generating the business cycle, but instead that capital investment principally underlies longer-term economic changes. It appears that the short-term business cycle arises from the interactions of inventories, order backlogs, production rate, and hiring and termination policies.[13] This alternative theory of the causes of the business cycle in turn calls for a different basis for economic stabilization policy.

III.A.2. CAUSES OF BUSINESS-CYCLE FLUCTUATIONS

Figure 1 shows a computer simulation of the production sector of the National Model, here representing a typical consumer-goods producing sector of the economy. For this simulation, capital equipment within the sector is held constant and production rate is changed by variations in labor only. A monthly, five-percent, random variation is superimposed on an otherwise-constant incoming order rate to the sector. Such a test input is used to exhibit the inherent dynamic periodicities of the sector.

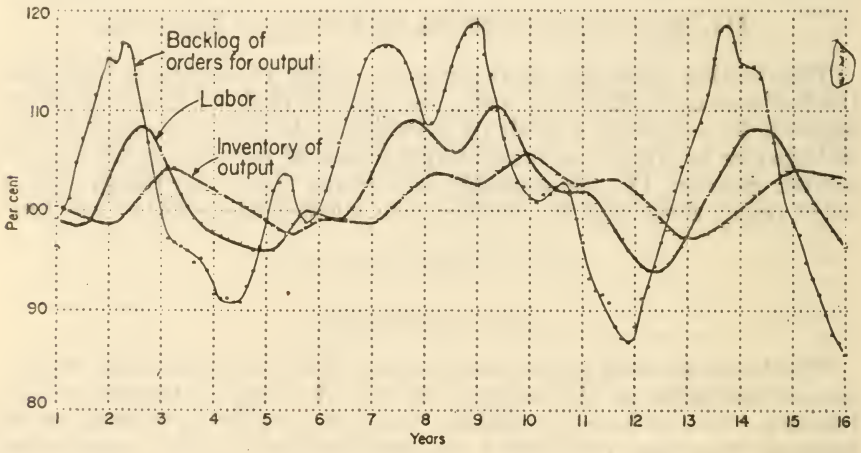


FIGURE 1.—Business-cycle fluctuations appearing in labor, inventory, and backlog.

In Figure 1, the production sector generates a sequence of fluctuations typical of the normal business cycle. Intervals between peaks vary around five years. Relative timing of backlog, production rate as shown by labor, and inventory are typical of industrial behavior.

The significance of Figure 1 lies in its generation of the business cycle without variation in consumer income or capital investment. Prices are not changing, demand is constant on the average, interest rates are constant, and capital investment is not involved. The cyclic fluctuation in Figure 1 has the major characteristics of the business

[13] See Mass (1975); Mass (1976b); and Forrester (1975) for more detailed treatment.

cycle and arises from the interaction of backlog, inventory, production, and employment. This is not to suggest that the business cycle operates without influencing other activities in the economy. But Figure 1 does raise the question of whether consumer income, investment, and monetary change are central to the generation and control of the business cycle or whether they are merely induced by variation arising from employment and inventories.

The fluctuating, business-cycle-like behavior in Figure 1 arises from policies that control employment in response to inventories and backlogs. Such policies tend to amplify disturbances and to convert short-term random disturbances into an irregular wave that reflects the natural oscillatory character of the system structure.

The reason for amplification and overshoot of employment and production can be seen by tracing the effects of an increase in demand (incoming orders) on the behavior of a typical firm. Assume that a constant demand has existed for consumer goods and that from this equilibrium condition demand suddenly increases slightly (Figure 2). The first consequence is an increase in orders, increase in the backlog for output, increase of shipments, and reduction of inventory of output. The increase in backlog and depletion of inventory continue until management has confidence that the new higher level of business is not an aberration and until additional factors of production (labor in this example) can be acquired to increase production. Between the time demand increases and the time that production rises to equal the new demand, three things occur. First, backlog for output increases to an undesirably high level; second, inventory of output is depleted below its initial desired level; and third, because demand is now higher than before, more inventory than at the beginning is needed to service the higher demand, and therefore desired inventory rises higher than at the beginning. As a consequence of these changes, when production has risen to equal demand, the system is out of equilibrium. Backlog for output is too high, and inventory is too low. Production must be pushed higher than the new demand to reduce the backlog for output, and to increase inventory not only back to its old value but up to the new higher desired level. When inventory and backlog reach the desired levels, production is apt to be too high so that inventory continues to rise. In turn, as inventory increases above its desired value, production rate must fall below incoming orders to reduce inventory. Through such mechanisms, a regular fluctuation in production rate, inventory, and employment can be generated.

It is from many such depletions of stocks and the need for excess responses to recover from the imbalances that fluctuating modes of the economic system arise. Disturbances propagate through a system by changing a stock from a desired level, setting up a discrepancy between actual and desired conditions, activating a policy to start a corrective sequence, and progressively working through a cascade of stages. Time lags in the system delay action and eventually induce corrections greater than the initiating disturbance.

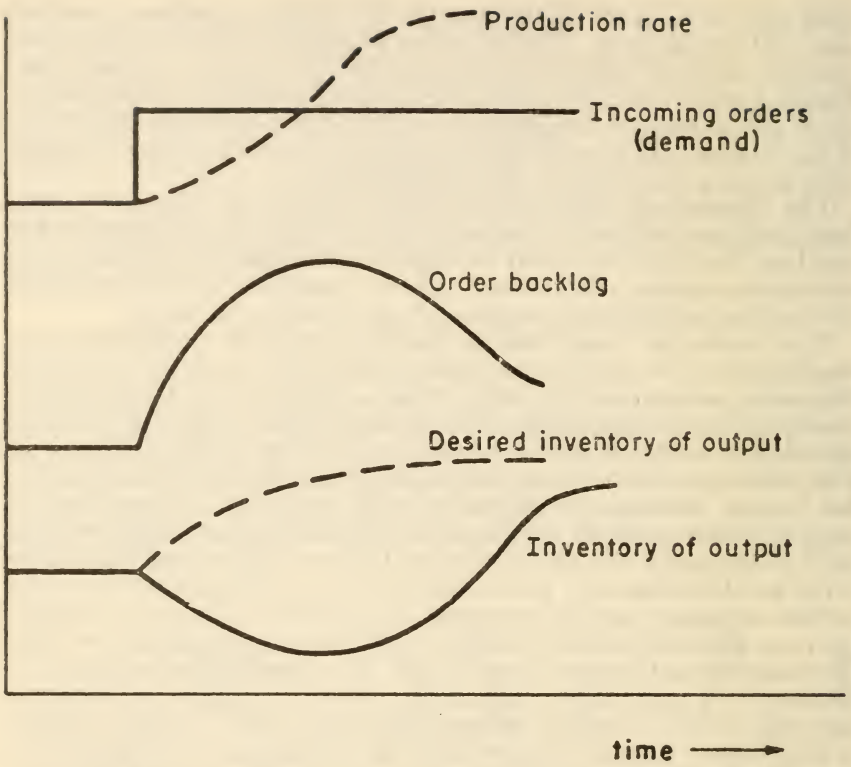


FIGURE 2.—Overshoot in production rate produced by interaction of inventory, order backlog, and production rate.

III.A.3. IMPLICATIONS

This preliminary examination of business-cycle behavior suggests that the business cycle primarily involves inventories and employment. Capital investment, although it will show fluctuation induced by the business cycle, need not be a necessary participant in creating the short-term business cycle. As shown later, capital investment policies appear to affect principally much longer-term modes of behavior than the business cycle.[14] Furthermore, the business cycle can exist without inputs from money supply, interest rates, or changes in consumer income. Therefore, monetary policies aimed at diminishing the business cycle through affecting investment may be coupled only very loosely to the primary causes of business-cycle fluctuation, and probably provide little leverage for influence. To summarize, development of enhanced policies for economic stabilization must proceed from

(1) Recognition of the multiple modes of economic change that influence economic activity; and

[14] See Mass (1975), Forrester (1975), and Mass (1976b) for more detailed description of economic behavior generated by capital investment. In particular, these works suggest that capital investment contributes primarily to the Kuznets cycle of some fifteen to twenty-five years duration and to the Kondratieff cycle or long wave.

(2) Recognition of the business cycle as arising principally from labor acquisition and inventory-management policies rather than from capital investment.

Section IV of the paper expands upon these implications.

III.B. *Long Wave*

III.B.1. BACKGROUND

The long wave is a fluctuation in the economy of some fifty years between peaks. It is characterized by sharp peaks in economic activity separated by long valleys of depression.

The long wave has been most extensively examined by the Russian economist Nikolai Kondratieff. Kondratieff showed that many economic time series in the Western economies had fluctuated with peaks around forty-five to sixty years apart. These time series, which include prices, wages, and interest rates, exhibited troughs around 1790, 1845, and 1895, and peaks around 1815, 1870, and 1920. Although Kondratieff's time series included data only through 1925, the massive depression of the 1930's would appear now as a trough of the long wave following the peak around 1920.

Kondratieff did not himself propose a complete or sharply-defined set of mechanisms that could account for the generation of a fifty-year cycle. However, he did argue that the cycle arose from the internal structural dynamics of the economic system. He did so by showing how events such as major technological innovations and fluctuations in population growth, which were commonly regarded as exogenous or external causes of the cycle, could in fact be seen as internal processes that interact over time to produce a long-wave fluctuation.

Today, many individuals and research groups are showing renewed interest in, and concern about, the long-wave phenomenon as severe economic difficulties are being encountered nearly fifty years after the Great Depression. Clearly, the long-wave phenomenon would be of great relevance to economic policy-makers if it is of underlying structural origin. Opinion is strongly divided on this point in the business and academic press. Many economists believe that the occurrence of the Great Depression was either accidental or a consequence of mismanagement by the Federal Reserve, and that the Depression could have been avoided through more judicious use of monetary policy.

Our research with the System Dynamics National Model suggests that long-period cyclic behavior can arise from interaction of internal economic processes, and that the cycle may not be controllable readily through conventional monetary and fiscal policy. In particular, a long-wave behavior can arise from the physical structure connecting consumer-goods sectors and capital producing sectors. A sufficient cause for a 50-year fluctuation lies in the movement of people between sectors, the long time to change production capacity of capital sectors, the way capital sectors provide their own input capital as a factor of production, the need to develop excess capacity to catch up on deferred demand, and the psychological and speculative forces of expectations that can cause overexpansion in the capital sectors. This theory of the long wave is detailed below, and some evidence is provided to demonstrate the pertinence of the theory to the current economic situation and as an explanation of the Great Depression.

Figure 3 shows two interconnected production sectors. Each production sector is a replication of the standard production sector of the National Model.[15] One sector has parameters for inventories and the time required to change production typical of a consumer durables sector and the other typical of a capital equipment sector. The consumer durables sector orders capital equipment from the capital equipment sector and has labor freely available (in the sense that the delay in filling vacancies for the sector is assumed to be constant). The capital equipment sector also has labor freely available but orders its capital equipment as a factor of production from its own output. Restriction on availability of labor will be included in the future when the

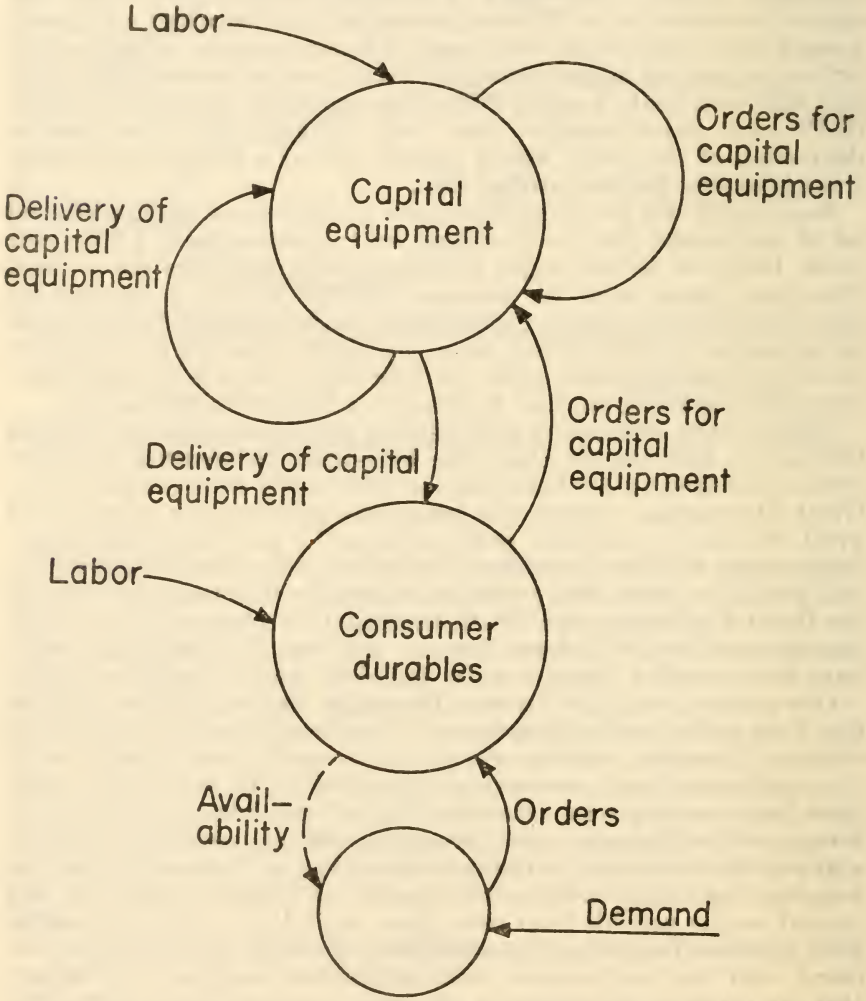


FIGURE 3.—Two-sector structure of consumer durables and capital equipment.

[15] See Section III.B for further description of the standard production sector.

labor-mobility networks are added to the National Model. This reentrant structure, in which the capital sector provides its own capital equipment, implies that an increase in demand for consumer durables would cause the consumer sector to try to increase both of its factors of production. It can obtain labor, but when it wants more capital equipment, the capital sector must expand. But if the capital sector is to expand in balanced manner, it needs both labor and capital as inputs. A "bootstrap" operation is involved in which the capital sector must withhold output from its customer (the consumer sector) so it can expand first in order to later meet the needs of the consumer sector. Such an interrelationship of sectors can create a mode of behavior not seen in either sector separately.

In Figure 4 the two-sector industrial structure shows a long fluctuation in the capital sector of some fifty years duration. The shape has similarities to the classical description of the Kondratieff wave in which steep peaks in economic activity are separated by broad valleys of depression. The model and its behavior in Figure 4 constitutes a theory of how the Kondratieff cycle can be caused.

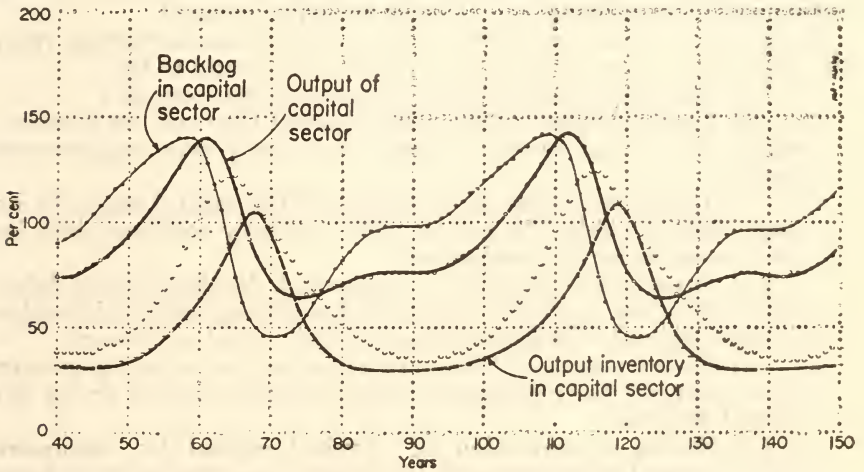


FIGURE 4.—Kondratieff cycle appearing in the capital sector.

Although the behavior behind Figure 4 is not yet completely understood, it seems reasonably certain that the processes of production and capital equipment procurement, and the relationship between consumer and capital sectors have the potential for producing a Kondratieff-cycle-like behavior. The mode of fluctuation in Figure 4 is strongly determined internally and is unstable for small variations and bounded by nonlinearities for large amplitudes. Such a mode grows quickly from any triggering disturbance and tends to sustain itself. It is especially persistent and not easy to influence unless its nature is well enough understood to discover any available points of leverage. If such a mode exists in real life, it is probable that changes over the fifty-year interval in psychological attitudes, propensity to take risks, and efforts to sustain the upward growth phase by monetary expansion will all tend to accentuate the fluctuation.

The most basic cause of the fifty-year fluctuation in Figure 4 is similar to the mode in Figure 1 that involved depletion of inventory and then an amplified production rate to reestablish internal balance. To illustrate the counterpart in Figure 4, consider the U.S. economy at the end of World War II. After the Depression and the War, the capital plant of the country was depleted at both the manufacturing and consumer levels. Automobiles were worn out, housing was inadequate, commercial buildings were old, and production equipment was obsolete. The physical capital stock of the country was at low ebb. But to refill the depleted pool of physical capital in a reasonable time, like twenty years, required a production rate greater than would be necessary to sustain the capital stock once the pool was filled. In other words, the production rate required to replenish the depleted physical capital in an acceptable period of time was higher than could be sustained. Moreover, as the order rate for capital in the consumer and goods-producing sectors of the economy began to decline, desired production in the capital sector declined, thereby lowering the need for capital equipment on the part of capital producers and accentuating the falling demand for capital equipment. The capital sectors would consequently overexpand and then be forced to retrench.

In more detail, the sequences in the long-wave mode, starting from the depression years at the bottom of the cycle, seem to be:

(1) Slow growth of the capital sector of the economy;

(2) Gradual decay of the entire capital plant of the economy while the capital sector is unable to supply even replacement needs;

(3) Initial recirculation of output of the capital sector to its own input whereby the capital sector initially competes with its customers for capital equipment;

(4) Progressive increase in wages and development of labor shortage in the consumer sectors that encourage capital-intensive production and still higher demands for capital equipment;

(5) Overexpansion of the capital sector to a capacity greater than required for replacement rate in order to catch up on deferred demands;

(6) Excess accumulation of physical capital by consumers (housing and durables) and by durable manufacturers (plants and equipment);

(7) Developing failure of capital equipment users to absorb the output of the overexpanded capital sectors;

(8) Sudden appearance of unemployment in the capital sectors;

(9) Relative reduction of labor cost compared to capital to favor a shift back to more labor-intensive production that further diminishes the desire for new plant and equipment;

(10) Rapid collapse of the capital sector in the face of demand below the long-term average needed by the economy to maintain the existing capital stock in the face of depreciation; and

(11) Spreading discouragement and slow decline of the excess capital stock through physical depreciation.

Such a chain of developments can underlie, as shown in Figure 4, large fluctuations in production and employment emanating from the capital-producing sectors of the economy.

III.B.3. EVIDENCE FOR CAPITAL-OVERINVESTMENT THEORY OF THE LONG WAVE

Investigation of this long-wave mode is incomplete. Yet is is of sufficient potential importance that even preliminary hypotheses are worth serious consideration. Present symptoms in the economy seem consistent with the top of a long wave when the top is viewed as a time of excess capital expansion. One example of such capital overexpansion is provided by observing that, for the first time since the late 1920's, many cities have today an excess of office space. A recent article in *Fortune* gives a good description of the psychological, financial, and speculative forces that lead to successive booms and depression of office-construction activity:

> The vacancy rate in Manhattan is now up to 18 percent, the highest since 1939 (though still below the peak of 1934). Worst of all, white-collar employment in the city has actually declined since 1969. The basic problem, surplus space, is not going to disappear for ten years or more, even if New York's office jobs start growing strongly again—and the prospects for that are dim. . . .
>
> But whereas fluctuations in interest rates and capitalization can be temporary, the key in the long run to the capital losses in Manhattan's office market today is the vast acreage of unrented space and the ensuing collapse of rental values. Indeed, if the financing of developers had proceeded in traditional fashion during the recent rampaging building boom, the matter of rates and capitalizations would be a minor issue. . . .
>
> Following the overbuilding that began in the late 1920's and ended with the Depression bust, the New York financial community set up in effect a tight "production control," which for nearly forty years prevented a repetition of the fiasco. Developers traditionally borrowed from the banks to finance projects, paying off construction loans with the proceeds from a permanent mortgage obtained from long-term lenders. But traditionally the developer could not get a full mortgage commitment from institutions without pretty firm leases in hand from solid, reliable tenants for about 75 percent of the planned space—and he couldn't get all the bank money he needed to erect a building without such a mortgage commitment.
>
> Over the years, however, this control weakened, and in the late 1960's it all but collapsed. Because of an extraordinary boom in white-collar employment from 1965 to 1969, both interim and permanent lenders thought the demand for new space was a sure thing, even without tenants on the dotted line. They began competing furiously for the right to finance new building. "There was a watering down of requirements in order to get the business," says Robert Schlageter, Equitable's senior vice president for mortgages.
>
> Banks for their part became eager to lend without the backup of permanent "takeouts" commitments. In that rich rental market of the late 1960's, moreover, most calculations assumed virtually 100 percent occupancy, top rental rates, and minimum expenses for alterations or concessions. . . .
>
> The result of this blithe approach was that flood of nearly 80 million square feet of space, 55 million of which reached the market after white-collar employment peaked in 1969.[16]

The above quotations describe several processes that are probably contributing strongly to present recessionary pressures in the economy arising from long-wave behavior: Changing attitudes toward risk; declining fears of major recession and consequent relaxation of debt standards in the face of nearly three decades of vigorous economic growth; speculative construction activity; and retirement of business and financial executives who lived through the Great Depression.

Relaxation of lending standards of banks and other financial institutions in the years following World War II has stimulated massive

[16] Carruth (1975).

capital investment and accumulation of debt on the part of nonfinancial corporations. Minsky has described these developments as follows:

> . . . at the end of World War II the financial system was very robust: banks were asset management institutions largely holding government debt, private business had large holdings of government debt and money and few debts. A similar picture ruled for households. Over the post war period financial changes accumulated: banks became liability management institutions when they ran out of debt for position making, corporations began to be heavy borrowers as well as short term lenders, and household debts grew enormously relative to income. The financial system evolved from being robust to being fragile.[17]

Figure 5 presents a variety of measures showing the increasing fragility of the commercial banking system in the U.S. since 1950. Such fragility probably underlies, to a large extent, the growing incidence of bank failures and mounting concerns for the safety and profitability of many surviving banks.

FIGURE 5.—MEASURES OF FINANCIAL CONDITION OF COMMERCIAL BANKS, UNITED STATES, 1951–73
[Percent]

	Financial net worth divided by total liabilities	No default assests [1] divided by total liabilities	Bought funds [2] divided by total liabilities
1951	7.4	58.3	3.7
1952	7.4	56.2	3.9
1953	7.5	55.9	3.8
1954	7.7	55.6	3.9
1955	7.8	49.6	4.3
1956	8.0	46.6	4.8
1957	8.2	45.3	4.8
1958	8.1	46.1	4.9
1959	8.3	40.7	5.1
1960	8.6	39.8	5.1
1961	8.5	39.9	6.9
1962	8.3	37.6	7.1
1963	7.7	33.6	9.0
1964	7.6	31.3	10.1
1965	7.3	27.9	11.6
1966	7.3	26.0	12.2
1967	7.0	26.3	13.1
1968	6.7	24.7	14.7
1969	6.7	21.4	16.9
1970	6.4	22.0	17.1
1971	6.2	21.9	17.2
1972	5.9	20.1	19.5
1973	5.7	17.7	24.3

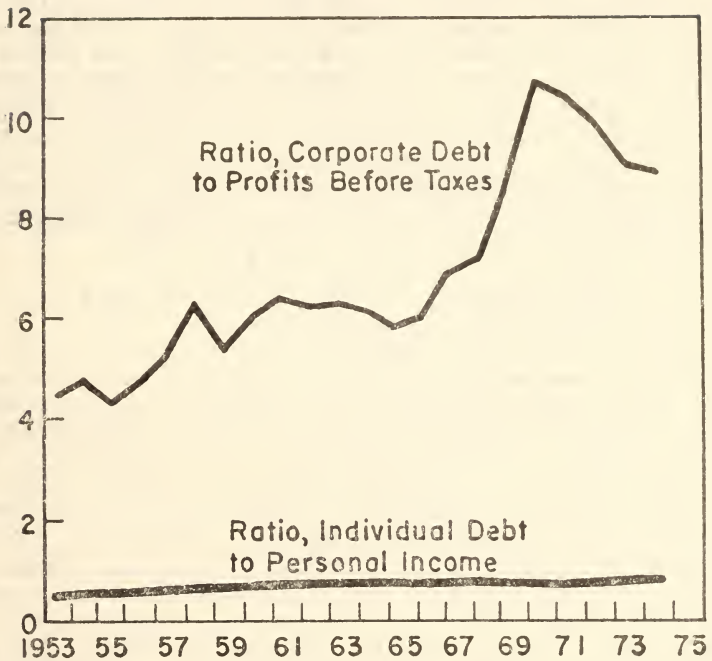
[1] U.S. Government securities, vault cash, and member bank reserves.
[2] Large negotiable L.D.'s, other inter-bank claims, credit market debt, liabilities to foreign affiliates, borrowing at Federal Reserve banks, and other miscellaneous liabilities.

Source: Board of Governors of the Federal Reserve System, Flow of Funds Accounts: 1945–72 (August 1973), and 1974 Supplement: 1965–73 (September 1974).

Figures 6 and 7 show the increasing burden of private debt. Figure 6 shows, for example, a more than doubling of the ratio of corporate debt to profits before taxes between 1953 and 1975. As suggested by Albert Sommers and Lucie Blau, such expansion of corporate debt reflects numerous factors, including "increased assurance with respect to business-cycle risk, particularly in the years since the successes of the 'new economics'." [18]

[17] Minsky (1974), p. 4.
[18] Sommers and Blau (1975), p. 30.

FIGURE 6.—Burden of private debt.



Source: Sommers and Blau (1975), p. 23.

FIGURE 7.—MEASURES OF FINANCIAL CONDITION OF NONFINANCIAL CORPORATIONS, UNITED STATES, 1951–73

[In percent]

	Fixed investment divided by internal funds	Internal funds divided by debts	Demand deposits divided by debts	Protected assets [1] divided by debts
1951	106.9	14.4	18.8	33.0
1952	95.8	14.7	18.5	31.5
1953	112.2	14.2	17.9	31.5
1954	100.4	15.3	18.5	30.7
1955	90.5	16.7	16.8	29.7
1956	106.6	15.4	15.4	25.1
1957	110.9	15.6	14.7	23.6
1958	100.3	14.2	14.5	23.5
1959	93.0	15.5	12.9	23.7
1960	103.8	14.5	11.5	20.6
1961	97.9	14.1	10.9	20.2
1962	93.1	15.5	10.4	19.7
1963	93.1	15.0	9.7	19.1
1964	90.6	16.1	9.1	17.4
1965	96.1	16.2	8.3	15.7
1966	101.6	15.9	7.6	13.7
1967	104.3	14.8	7.4	12.9
1968	111.1	13.2	6.9	12.0
1969	126.7	11.7	6.7	10.3
1970	131.9	10.6	6.4	10.1
1971	120.8	11.3	6.0	10.5
1972	117.8	12.0	5.5	9.7
1973	128.4	11.4	4.8	8.5

[1] Demand deposits, time deposits plus Government securities.

Source: Board of Governors of the Federal Reserve System, Flow of Funds Accounts: 1945–72 (August 1973), and 1974 Supplement: 1965–73 (September 1974).

Increased debt is today threatening profitability and stability of many businesses. Such funds have largely been channeled into capital investment, as manifested in a very rapid expansion of nonresidential fixed investment since 1953, and particularly since 1965. For example, Sommers and Blau note that "the real growth in plant and equipment outlay has been faster since 1965 than it was in the preceding twelve years.[19] " At the same time that capital plant has been growing rapidly, however, capacity utilization rates in manufacturing have declined significantly, from 90% in 1965 to around 65% in 1975.[20]

To summarize the preceding description, empirical evidence shows:

(1) A growing fragility of commercial banks;
(2) A rising burden of corporate debt;
(3) Rapid expansion of capital investment; and
(4) Declining rates of capital utilization.

These long-run economic developments suggest a variety of strong recessionary pressures that need to be understood better in the broad context of economic stabilization policy and the long-wave behavior.

In addition to the evidence cited above, the national economy today exhibits a number of other indications of overinvestment in capital plant: New tankers are leaving the shipyards and going directly to anchorage. Aircraft are going into storage. The interstate highway system is nearly complete and another is not needed soon. The condition of the auto industry only partly results from the oil shortage and is partly due to the consumer stock of automobiles having been filled. The financial plight of the real estate investment trusts and the decline in home construction suggest that we already have more housing than the economy can support. Most municipalities have built sufficient schools and hospitals. Finally, college-educated persons, a form of human capital with dynamic characteristics similar to those of physical capital, are in excess as evidence by high unemployment rates.

It is illuminating from the standpoint of the present economic situation to apply the capital-investment theory of long-wave behavior developed in this paper to the circumstances surrounding the Great depression. Although the Great Depression is frequently attributed to bad luck or monetary mismanagement, a careful reading of the economic history of the 1920's portrays a strong investment boom leading to overexpansion and a drying-up of new investment opportunities. This history resembles closely the theory of long-wave behavior suggested by our research. In addition, several historical aspects of the Depression, such as the rapid buildups of corporate and household debt, increase in speculative construction, and high rate of capital investment, are similar to present conditions in the U.S. The following quotations describing the 1920's are from Robert A. Gordon's book, *Economic Instability and Growth: The American Record:*[21]

> The outstanding fact about the movement of total capital formation in this decade [the 1920's] is the high level reached by 1923 and the maintenance of this level for seven years. We have here a prolonged period of high-level investment in producer durable goods and construction. . . . *It is significant that both producer and consumer durables formed a larger fraction of the GNP during the 1920's than during any period before World War I. We thus have a picture of a prolonged investment boom, which supported a steady expansion in incomes and consumer demand, and at the same time provided the enlarged capacity necessary to meet the rising demand for goods and services* [emphasis added]. . . .

[19] Ibid., p. 34.
[20] Ibid., p 15.
[21] Gordon (1974), Chapters 2 and 3.

The investment boom and the rise in consumption during the 1920s were accompanied by a steady expansion in bank credit, the flotation of an enormous volume of new security issues, and a mounting tide of speculative fever reflected particularly in the promotion of new enterprises, a boom in real estate, the development of a variety of unsound financial practices, and an upsurge in stock prices that culminated in the stock market crash of 1929. . . .

We have already mentioned the importance of construction in maintaining investment in the 1920s. . . . The most important single component of new construction was residential building, which comprised 40 percent or more of the total through 1926, when a decline set in that lasted until 1933. . . .

The decline in residential building after 1926 reflected a number of factors. The high level of construction in the early and mid-twenties eventually permitted the supply of housing to catch up with demand; . . . The satisfaction of pent-up demand would by itself have called for some decline in building, and overbuilding made the situation worse. . . . Thus 1926 marked the peak of another long building cycle. . . . It is doubtful whether these monetary developments were of primary importance in creating the boom of the 1920s. In the terms used by some business cycle theorists, the "natural rate" of interest was higher than the market rate, and part of the large volume of investment was financed by credit expansion. But the chief reasons for this lay in the nonmonetary sphere—in the developments discussed earlier that made the marginal efficiency of capital high and in the wave of speculative optimism that raised it still higher. In addition, the upwise lending practices of the commercial banks encouraged speculation and unsound promotions, and weakened the banking system's ability to withstand the strains that were to come after 1929. . . .

. . . Houses, apartment houses, office buildings, and hotels were built with almost reckless abandon under the spur of promoters' profits and the ease with which securities could be sold to finance the cost of construction. Banks loaned heavily on bonds and mortgages, without adequate safeguards as to amortization, and later found themselves with "frozen assets" whose values had to be scaled down drastically.

The consequences of these financial developments need no great elaboration. One result was a good deal of real investment that was not justified in terms of long-term profit possibilities. Capital goods were created that were to "hang over the market" and discourage further investment for a decade after 1929. The banking system was seriously weakened. Many weak business ventures were saddled with a load of fixed charges that could eventually lead only to the bankruptcy court. . . .

It is impossible to give a complete and precise statement of the immediate causes of the downturn. Certainly the full explanation of the extent and severity of the Great Depression is not to be found merely in the sequence of events during 1928–1929; we must look at boom [sic] of the 1920s as a whole and at the course of developments during 1930–1933. . . .

Although we cannot complete our explanation of the causes of the Great Depression until we look at developments during the 1930s, we can dispose of a number of possible hypotheses as to the major cause of the downturn in 1929. It was clearly not due to an encroachment of costs on profits. . . .

Nor can the downturn be explained by monetary developments. The rise in interest rates was not great enough to discourage business borrowing; the Federal Reserve authorities were careful not to restrict credit for legitimate business purposes. We have already seen that business was becoming increasingly independent of the banks, and commercial loans did not begin to decline until after the stock market crash. . . .

. . . What we have said in earlier sections suggests that the following factors were chiefly responsible for the magnitude of the catastrophe that occurred.

1. The exhaustion of investment opportunities resulting from (a) the working of the acceleration principle in industries approaching maturity and (b) the creation of considerable excess capacity, particularly in residential and commercial building.

2. The financial excesses of the 1920s, which at the same time led to too rapid a rate of real investment in some industries and created a superstructure in inflated capital values whose collapse weakened the banking system and caused both borrowers and lenders to take a pessimistic view of the feasibility of further investment.

> There remains the question: Why was the recovery of the 1930s so slow and halting in the United States, and why did it stop so far short of full employment? We have seen that the trouble lay primarily in the lack of inducement to invest. Even with abnormally low interest rates, the economy was unable to generate a volume of investment high enough, given the propensity to consume, to raise aggregate demand to the full employment level.

To summarize the preceding quotations from Gordon, it appears that the 1920's represented a period of rapid capital accumulation that led to an overexpansion of the capital-producing sectors of the economy. Such overexpansion caused a severe diminution of investment opportunities and consequent strong recessionary pressures. Gordon argues that the Great Depression was thus in large measure a result of a collapse of new capital formation, and that the Depression was neither adventitious nor a simple result of poorly-conceived government policy. Gordon's description lends support to the proposition that the long-wave mode is generated from the interplay of internal economic and social forces: in particular, it lends support to the capital investment theory of the long wave developed in this paper.

III.B.4. IMPLICATIONS OF THE LONG-WAVE THEORY

If we are indeed moving from a condition of rapid capital accumulation to one of excess capital stock both at the industrial and consumer levels, the implications for business and economic policy are substantial. A downturn of the long wave arising from capital overinvestment would yield retarded growth and long-term unemployment radiating from the capital sectors of the economy. Appropriate government policy for dealing with such changes will need to be developed.

Countercyclic monetary policy, discretionary fiscal policy, and other "fine tuning" mechanisms have often been given credit for reducing business downturns between 1945 and 1970. However, one alternative explanation for the decreased severity of the business cycle in the postwar years stems from considering the interaction of the business cycle and the long wave. If the U.S. economy is characterized by a short-term business cycle superimposed on a much longer-term cycle, then business-cycle expansions would naturally tend to be relatively long, and contractions short, during an upswing of the long capital cycle. Thus, it is possible that the apparent lessened vulnerability of the economy to recession following World War II is attributable to the rising phase of the long wave, with little or no contribution from government policy. This argument is illustrated further below.

Figure 8 shows two sinusoids as stylized representations of the business cycle and long-term capital cycle.

Figure 9 and Figure 10 are on an expanded time scale and show the simple sinusoids added together. The numbers give the time in years for economic expansions and contractions. Figure 9 covers the rising segment of the long wave and Figure 10 the falling segment. Note that the upward thrust of the long wave before the peak in Figure 9 gives business cycles the appearance of having strong and long expansions with weak and short recessions. By contrast, in Figure 10, which shows the falling phase after the peak of the long wave, the long-term decline weakens and shortens the expansion phase of the

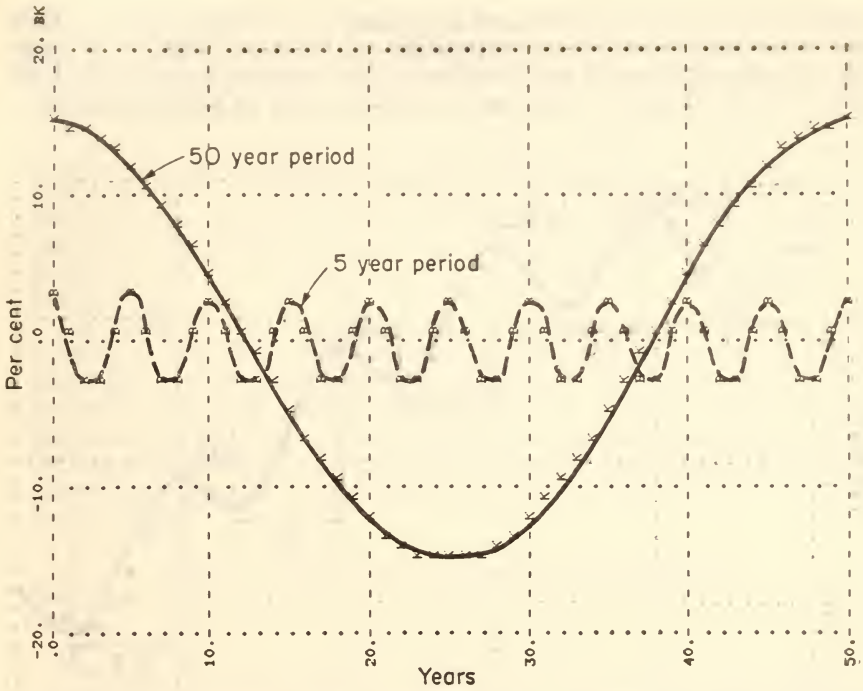


FIGURE 8.—Two sinusoidal curves representing the business cycle and the long wave.

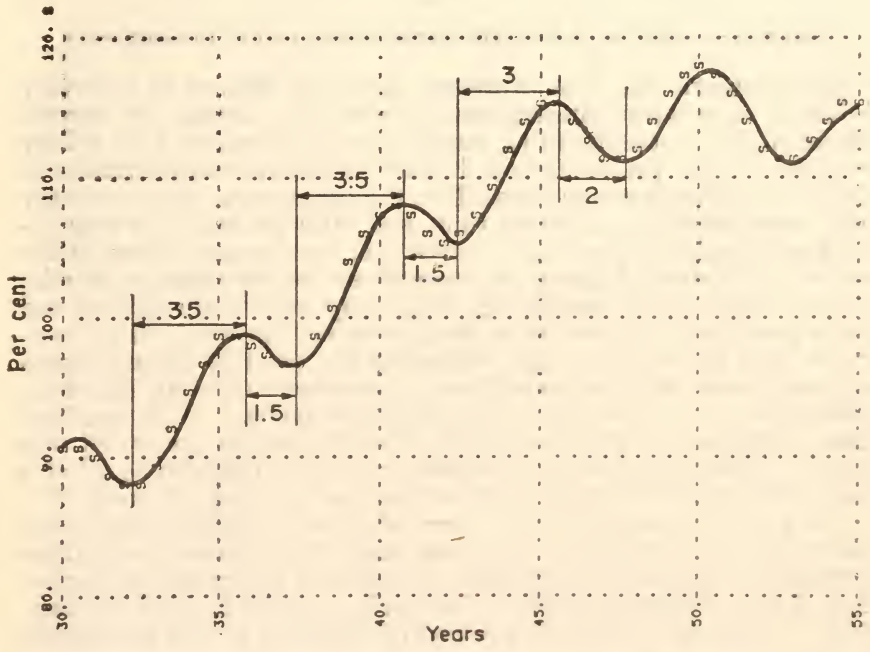


FIGURE 9.—Addition of sinusoids during rising part of the long wave.

business cycle and deepens and lengthens the recession phase. With no other influences, the superposition of business cycle on a long-term fluctuation would produce the milder recession since World War II, without relying on post-war monetary policy as an explanation.

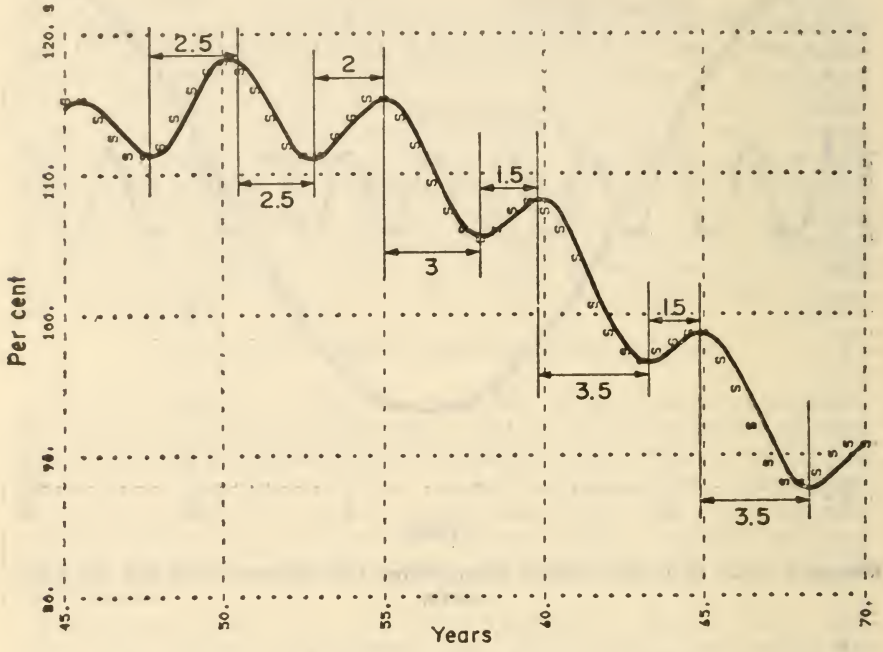


FIGURE 10.—Addition of sinusoids during falling part of the long wave.

Much concern has been expressed about the failure of monetary policy to cope with faltering economic activity during the current recession. The assumption that monetary policy accounted for milder recessions in the preceding two decades underlies disappointment in the lack of present effectiveness. But, the explanation may be simply that monetary policy has at all times had little leverage over employment and the level of economic activity. If the economy is now at the top of a Kondratieff cycle, the more severe recent recession is adequately explained by weakening of the long-wave upthrust that had given preceding business cycles their apparent buoyancy. These comments, and their implications regarding the possible ineffectiveness of government stabilization policies, are consistent wth Carl Madden's observation that "The era of the 'New Economics' . . . is receding. The optimism for 'fine tuning' the New Economics generated now seems in the face of the economic history of the 1960's to be all of a piece with the intellectual hubris of the best and the brightest." [22]

But even if monetary policy were effective in dealing with recessionary pressures emanating from the short-term business cycle, there is reason to suggest that expansionary monetary policy may be ineffective, or even counterproductive, for dealing with a long-wave downturn. A long-wave decline is a period of depressed capital investment

[22] Madden (1975), p. 2.

as a consequence of prior overinvestment. The interval of reduced investment allows time for the capital plant of the nation to wear down toward an appropriate balance with other aspects of the economy. Under conditions of excess capital plant, increasing the money supply will provide little incentive for purchase of physical capital and instead may only feed speculative and inflationary forces. Alternatively, to the extent that monetary policy has any influence on the long-wave behavior, the principal effect may be to prolong the peak of the long wave by stimulating investment in the short run, but causing an eventual steepr decline as even more excess capital plant is accumulated.

As discussed above, existence of a long wave in the economy poses numerous dilemmas for government policy. The long-wave theory provides an explanation for the precipitous depression of the 1930's, makes it unnecessary to invoke government policy to explain either the Great Depression or the milder recessions in the 1950's and 1960's, and accounts for the worse recession recently encountered. Section IV expands upons the implications of the long-wave mode for government policy.

III.C. *Life-Cycle of Economic Development*

III.C.1. BACKGROUND

Over most of the past 200 years, the United States has enjoyed a relatively sparsely-occupied geographic land area with abundant natural resources. Under such favorable circumstances, population and industrial activity have tended to reproduce themselves in such a way as to promote cumulative growth. For example, a higher population produces higher births, thereby contributing to further population expansion. Analogously, more capital plant (industrialization) yields a higher output stream and greater output allows more investment in capital plant through increased production of buildings, machinery, and other forms of physical capital. Exponentially-growing population and production have, in turn, generated rising demands for food, energy, and other renewable and nonrenewable resources.

After two centuries of relatively sustained and vigorous growth, the carrying capacity of the United States is becoming stressed. Past growth in population, consumption, energy usage, and pollution generation is beginning to trigger strong counterpressures.

The life cycle of economic development refers to the S-shaped, or logistic, curve wherein growth gives way to maturity that in turn is followed by either equilibrium or decline. It is from the dynamics of the life cycle that the phrase "limits to growth" emerges. If there were no limit to resources, energy, water, pollution-dissipation capacity, or land area, then growth of population and industrialization could continue indefinitely. But at some point growth becomes bounded by environmental capacity.

The life cycle of growth can be subdivided into four time phases (Figure 11). First is the period of exponential growth during which growth is uninhibited by proximity to ultimate limits. Second is the transition region lying about halfway up the growth curve, at which point enough resistance to growth is being encountered to move the system out of its growth mode and into an equilibrium-seeking mode.

Third is an equilibrium region of no growth with population and economic activity restrained by environmental capacity. Fourth may be a decline phase such as has usually been encountered by nations and institutions.

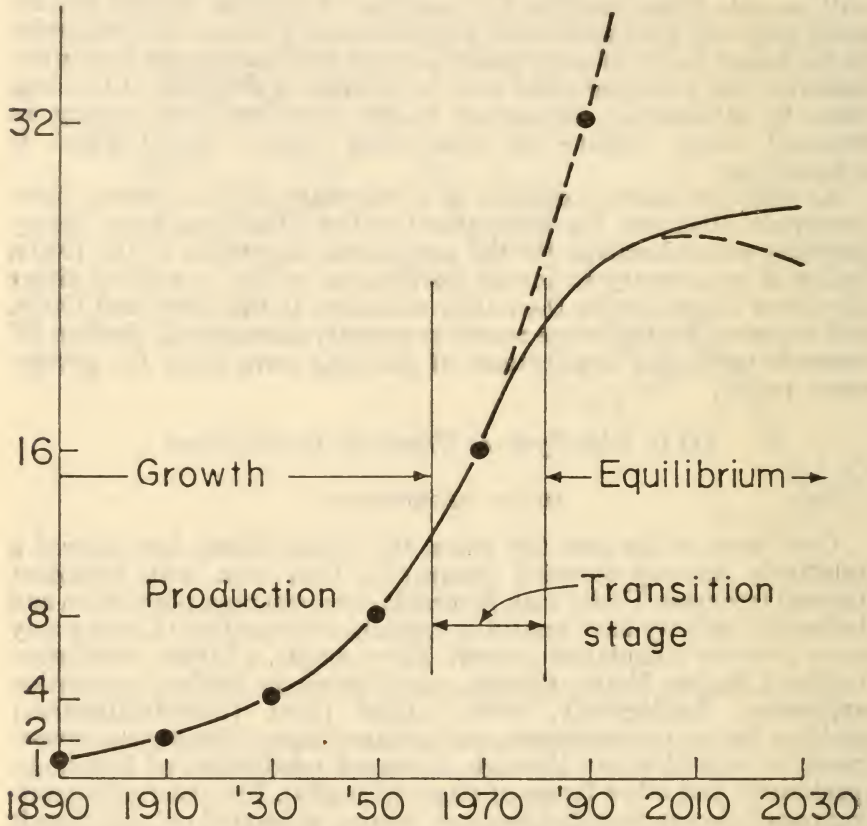


FIGURE 11.—Life cycle of economic development.

There are signs emerging that the American socio-economic system is in the second phase—the transition region separating exponential growth from equilibrium. The transition region is at the point of inflection where upward curvature in growth gives way to downward curvature as growth slows and moves toward its peak. The transition region marks the division between accelerating growth and decelerating growth.

It is in the transition region that the greatest social and economic stresses occur. In the transition region, the forces opposing growth become great enough to suppress the powerful mechanisms of growth and to change the behavior mode of the system from accelerating exponential growth to a slowing and stopping of growth. When equilibrium has been reached, society will have come to terms with the new condition. It is in the transition region that the pressures are greatest and the maximum rate of change occurs in expectations, attitudes, and values. The transition region is consistent with the

social, environmental, and inflationary forces that are developing in the U.S. The transition stage is a time of turbulent change as the system moves out of the growth mode.

III.C.2. LIMITING FORCES ARISING WITHIN THE LIFE CYCLE

The limiting forces that arise in the transition region to restrict growth of population and production can be divided broadly into two categories: physical and social limits. Each of these categories is discussed briefly below.

Physical limits

(1) *Food Shortage.*—Food shortage represents one physical limit which may confront the United States before long. The most productive arable land in the United States is already under cultivation. Thus food production in the nation can be expanded in the future either by cultivating relatively infertile and unproductive land or through increases in yield per acre. Expanding available arable land, however, will entail high costs for irrigation, land development, and fertilization. Much higher per-acre yields than at present also appear unlikely. To expand yields significantly, increasing amounts of fertilizer and irrigation would be required at the same time as energy prices are rising rapidly and water tables are being drawn down as irrigation and other claims on underground water supplies begin to exceed the recharge rate. Agricultural output and food processing in the United States are heavily energy-intensive operations, requiring nearly nine calories of energy to produce one calorie of food output.[23] Such energy intensive agriculture will be less profitable or feasible in an era of high energy prices.

The agricultural problem is compounded by the fact that approximately one half million hectares of cropland are being converted annually to housing and other urban-industrial activity. This figure implies that over the past twenty years a land area larger than Ohio has been converted from farmland to cities and highways.[24]

Rising food needs have also caused agricultural land to be used more intensively by reducing fallowed acreage. As Lester Brown and others have indicated, reduced fallowing tends to cause lower moisture content in soil and, consequently, lower agricultural yields and potential soil losses to wind and water. The potential seriousness of the agricultural output situation is suggested by rising food prices and the fact that the U.S. government had to impose unilateral export restrictions on soybeans and feedstuffs in June 1973, to fight domestic food inflation.

(2) *Resource Shortage.*—Natural resources comprise a second important array of physical limits. The United States is presently a net importer of 26 of the 36 "critical" raw materials.[25] For example, the recent ERDA report, "A National Plan for Energy Research, Development, and Demonstration," notes that the United States is almost entirely dependent on foreign supplies of aluminum, chromium, and

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[23] Steinhart and Steinhart (1974), p. 312. The calorie-conversion figure quoted here is for energy calories input per energy-calorie output of food. In nutrition, the term "food calorie" actually measures one thousand energy calories.

[24] Pimentel, Dritschilo, Krummel, and Kutzman (1975), p. 760.

[25] Ewell (1970), p. 43.

alloying elements for steel. Supplies of many materials and natural resources are presently critically low, having been drawn down and depleted through two centuries of exponentially-growing population, consumption, and production. Moreover, the average grades of many resources such as copper are declining as progressively less efficient resources must be extracted and utilized in production processes.[26] The combination of decreased resource availability, rising prices, and diminished resource efficiency threatens to curtail continued expansion in national standard of living.

(3) *Energy Shortage.*—The issues surrounding energy shortage in many ways parallel natural resource questions. In 1973, petroleum consumption accounted for nearly 50 percent of total domestic energy usage. Natural gas accounted for an additional 31 percent.[27] Thus, nearly 80 percent of total U.S. energy requirements in 1973 were met through depletable energy sources that are in short domestic supply. Imported oil, for example, exceeds 50 percent of domestic oil production so that domestic oil consumption exceeds production by over one-third.[28] The natural gas situation is, in some respects, still more severe. In 1969, domestic production of natural gas exceeded additions to reserves by a factor of approximately 2.5.[29]

The dynamics of energy shortage and resource shortage both develop out of growing production and consumption in the face of finite, nonrenewable supplies. As labor, capital, and other factors of production are used to generate output, nonrenewable resources, including fossil fuels, are consumed in the process. As resources are consumed, the total amount of resources extracted (measured, for example, in tons of resources) rises. Increased extraction, in turn, raises the "real costs" of resource extraction, processing, and distribution. "Real costs" here mean the amount of labor, capital equipment, energy, and planning that must be devoted to extracting and utilizing an additional unit of resources. As total resources extracted rise, mines must be dug deeper, and drilling must be attempted in less accessible locations, in order to obtain resources. At the same time, the probability of discovery declines. Moreover, to the extent that the most accessible and highest quality resources are extracted first, the average grade and quality of remaining resources becomes progressively lower. High-cost recycling techniques may also have to be adopted to sustain the flow of resources. All of these effects imply that more effort and more physical and financial resources must be diverted to the resource and energy sectors even to maintain a constant output. In other words, as a consequence of resource depletion, the production function of the energy and resource sectors shifts downward so that given amounts of labor, capital equipment, energy, and other factor inputs now yield less output of energy and resources. Growth in resource and energy usage thus becomes progressively harder to sustain and the economy undergoes a "real" inflation caused by falling productivity and declining extraction efficiency.

The significance of rising real energy costs can be seen in the fact that, for several years now, petroleum discoveries in the United States have been declining due to depletion of accessible and low-cost

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[26] Committee on Resources and Man of the National Academy of Sciences (1969), p. 124.
[27] Energy Policy Project of the Ford Foundation (1974a), p. 75.
[28] Energy Policy Project of the Ford Foundation (1974b), p. 28.
[29] American Gas Association (1970).

petroleum reserves at the same time that demand for and usage of petroleum have been growing.[30] The combination of falling production and rising demand has yielded a gap that, in turn, has led to depleting proven reserves of petroleum and to high import demand. Finally, increased dependence on imported oil has led to rising oil prices, reduced domestic standard of living, and increase international tensions.

(4) *Tradeoffs Between Physical Limits.*—A range of additional physical limits could be described—for example, overcommitment of pollution generation capacity; excessive thermal heat generation; and shortages of water, wood, and other renewable resources. Our purpose, however, is not so much to describe in detail the functioning of each potential physical limit as to point out the existence of multiple physical limits of which energy shortage is an example. The physical limits all tend to be triggered by rising population and industrialization.

Strong tradeoffs can exist between the various physical limits to growth. Thus, alleviating the energy shortage promotes further growth that causes more pollution, higher demands for food and raw materials, and conversion of agricultural land to urban-industrial use. A transfer of pressures can thus occur between limiting factors so that an energy shortage shifts to a materials shortage, a food shortage, or other manifestations of physical stress. National policy must therefore be predicated on a broad understanding of the tradeoffs between physical limits engendered by alternative policy actions.

Social limits

Growth is simultaneously encountering many limits. So far, world attention has focused on the physical limits of food, pollution, resources, and energy. But other limits lie just beyond the physical limits.

Social limits are already exerting powerful forces. The social forces are related to rising population density, growing industrialization and capital-intensive production, and expanding technology. As crowding becomes greater, life becomes more complex. Friction between individuals and groups increases. Political conflict intensifies. Inter-group rivalries increase. Overcrowding of physical space leads to public conflict with business, as manifested by disputes over power plant siting, strip mining, and pollution emissions. Psychological stress, community breakdown, rising crime rates, drug addiction, genocide, revolutions, and war can all be seen as manifestations of social stress engendered by rising crowding and population density.

The processes of growth in production, capital intensity, and technology also foster social stress. Energy- and machine-dependent production today deemphasizes the human contribution to work, leading to alienation and personal dissatisfaction. Large-scale production processes, mass production, and specialization all divorce the individual from a sense of personal contribution or achievement. Feelings of distrust and questioning of the legitimacy of institutions tend to deepen. A complex technological society is at the same time harder to understand, more difficult to accept, and easier to disrupt.

[30] Energy Policy Project of the Ford Foundation (1974a), p. 75.

The above discussion has tried to convey the general nature of social limits. Such influences are relatively subtle and intangible, stemming from the interplay of psychological motivations at the individual and group levels, and from societal attitudes and values. Nonetheless it apppears that social limits are exerting increasingly powerful influences on U.S. society. These limits are simultaneously making consensus on directions for the nation progressively harder to achieve, and making management of the society progressively more intractable.

III.C.3. IMPLICATIONS OF THE LIFE-CYCLE MODE

The United States may now be entering into a period of slower growth arising from the long-term growth restraints that emerge within the transition region of the life cycle of economic development. The life-cycle mode thus contributes to retarded growth, expanded unemployment, and inflationary pressures focused in the areas of energy, food, land, and materials. In many respects, the growth restraints associated with the life cycle are more social, demographic, and environmental than they are economic in nature. In such a national environment, stimulative fiscal and monetary policy may exert more of an inflationary impact than it contributes to expanding real output. As Carl Madden notes:

> . . . we may be in the early stages of a profound confrontation between the appetites of industrial civilization and the physical limits to growth on the planet. Conventional neo-Keynesian economics alone hardly suffices to cope with any such confrontation. . . . The United States, even though it is affluent, is not the limitless cornucopia of recent popular thought. . . . Caution should behoove us to concede the possibility that old ideas in economics, such as the Keynesian ideas of forty years ago, may not be safe to be fully trusted. Simple faith in faster money creation and still larger governmental deficits that is generated by the econometric models, say, of the new Congressional Budget Office, may only bring uncomfortably queer results of stagflation, of recoveries stopped in mid-passage by renewed inflation and rising, not falling, unemployment.[31]

The severity and types of pressures encountered by the U.S. in the transition region will certainly depend on future attitudes toward immigration and family size and on technological developments. Regarding population growth, present U.S. fertility rates are below the population replacement rate. But such fertility rates, even if sustained, would lead to a more-than-fifty-percent increase in population before population equilibrium is attained. Such increase in population would result from the large number of adults of child-bearing age presently in the U.S. as a consequence of past rapid growth in population, especially around World War II.[32] In the future, a slower rate of U.S. population growth would tend to diminish physical and social stress. However, if lower stress and consequent greater well-being lessen concern over population and trigger a resurgence of population growth, then over the long term, pressures wil not be significantly reduced.

Technological changes can also be expected to exert a future impact on economic growth and well-being. But such changes may not be unilaterally favorable or desirable. If technological developments push

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[31] Madden (1975), pp. 3, 4.

[32] Freika (1968). Thus the number of persons born per year depends both on fertility rates and on the age structure of the population.

back physical growth limits leading to continued growth, that additional growth may quickly swallow up the margin of available space and resources while encouraging greater population. Technological developments may also tend, as discussed earlier, merely to shift pressures from one growth-limiting factor to another; such tendencies increase with growing population density and with increasing social complexity. National growth policy must not, therefore, be predicated on a simple expectation or hope that technological growth or temporary slower population growth will relieve the growth-limiting pressures confronting the nation, but should be based on a deeper understanding of interactions between population, technological change, well-being, and the various physical and social limits.

The life cycle may also interact with the short-term business cycle and long wave to accentuate economic instability. Through its inflationary influence in the transition region, the life cycle contributes to rising prices of goods and various raw materials. Such rising prices, in turn, lead to speculative inventory purchases in anticipation of still further price increases. These speculative purchases tend to buoy demand, inducing higher prices and expanded production in the short run. But eventually as production capacity expands, price rises begin to slow, and advance inventory purchases consequently decline, leading to overexpansion and overbuilding of inventories. Such excess inventories can be liquidated only through declining production and employment.[33] The influence of the processes explained above in fostering economic instability is suggested by a quote taken from the *Wall Street Journal* in 1974:

> A stream of revised statistics from the Commerce Department has led to increased worry among economists that the nation may, after all, be in for a classical case of what's known as an inventory recession. Coming on top of the current slump, this could mean that the economic downturn would be deeper and longer than has been expected. . . . Most of the accumulation so far this year has come in manufacturing, and most of that is in purchased materials and supplies. Some of the building undoubtedly stems from buying to beat price increases. Many firms are hoarding goods that already are scarce or that they fear may become so.[34]

To summarize, then, the life-cycle mode contributes to slackened growth, high unemployment, rising prices of energy, agricultural commodities, and materials, and heightened instability. Development of government policies to deal with such difficulties must stem from a deeper understanding of the diverse limits to growth encountered in the transition region, their individual characteristics, and the ways in which they interact and trade off against one another.

IV. Policy Directions and Implications

Development of policies to alleviate the social and economic stresses confronting the U.S. today must begin from an understanding of the short-term dynamics of the business cycle, the structures that produce a fifty-year long wave, and the life cycle of economic development. For the first time in the nation's history we may face the triple coincidence of a business downturn, a long-wave collapse, and the pressures of the transition region. The three could combine to depress economic activity

[33] See Mass (1975), Section 3.6, for a more complete description of these processes.
[34] Wall Street Journal (August 16, 1974), p. 24.

and national standard of living unless public understanding of these behavior modes is increased and suitable national policies are adopted.

The purpose of this paper has been to expand awareness of the longer-term economic and social forces that will become increasingly influential over the next ten to thirty years. Failure to recognize these long-term forces can lead to governmental actions that are ineffective or which make matters worse. The result would be an intensified sense of public futility and increased dissatisfaction with government.

The issues raised here are based on work that is still in progress. We believe that much additional light can be shed on the issues as continued research into the dynamics of the national economy yields a deeper examination of the sources of unemployment and inflation, and the channels connecting government policy and private action. Even at the present time, however, the preliminary insights surrounding the business cycle, the long wave, and the life cycle of economic development, seem sufficiently important and persuasive to merit serious discussion and debate in this Committee and in the public forum. The time that will be required to achieve public understanding of long-term issues and to form a subsequent legislative consensus is sufficiently long to merit exposure of the issues to a broad audience even at a preliminary stage. Therefore, the following points summarize the principal implications and policy directions that can be derived at the present time from our analyses of long-term economic growth.

(1) *Recognizing the multiple modes of economic behavior.*—Present economic difficulties may arise from a confluence of three modes of economic behavior: the business cycle, the long wave, and the life cycle of economic development. Erroneously attributing all symptoms of difficulty to the short-term business cycle can lead to incorrect diagnosis of causes and to consequent adoption of ineffective government policies. Congressional debate on economic policy should recognize these three modes of behavior. In particular, proposed actions and legislation should be evaluated from the standpoint of which modes of behavior they are designed to address, and how the proposed policy will affect each mode.

(2) *Understanding the nature of the recent recession.*—The greater severity of the recent recession may be an indication of the top of a long-term capital cycle, leading to an excess of capital plant. The recent recession may thus be of a substantially different nature than other recessions since World War II. Evidence for an emerging capital excess is seen in the decline of capacity utilization rates, high unemployment rates of college-educated persons, growing debt burden on corporations, faltering growth in housing construction and machine tools, appearance of excess office space in major urban areas, and other symptoms. In the falling phase after the peak of a long wave, business-cycle downturns would tend to be relatively long and expansions brief, whereas the opposite relation held during the long-wave upsurge. The causes of the recent recession and possible future recessions must be understood in order to formulate correct policy responses.

(3) *Expanding the time frame of stabilization policy.*—The long wave, of some 45 to 60 years duration, may exert a far greater disturbing force on the economy than the short-term business cycle. Such a long-wave mode can arise from typical capital investment policies within the economy. Thus government policies affecting interest rates

and investment incentives may exert their primary effects on the long-wave mode rather than on the business cycle. The scope and time horizon of economic stabilization policy must be broadened from the present outlook of a few months to several decades.

(4) *Understanding the causes of the business cycle.*—The short-term business cycle appears to be caused primarily by interactions between inventories and employment. Capital investment does not seem to be a fundamental contributing cause of the business cycle. Seeing the business cycle in terms of inventories and employment implies that present monetary policies designed to stabilize the business cycle by influencing the incentives for capital investment may exert only low leverage for control. Alternative bases for stabilization policy consistent with causes of the business cycle must be sought. New policies should attempt to dampen the amplifying effects of inventory-management policies on production and employment (see Section III.A). To this end, new policies such as rules requiring businesses and households to maintain money balances in proportion to the rates of flow through those balances should be considered.

(5) *Policies for dealing with the long wave.*—Appropriate policies for controlling the long-wave mode may differ quite substantially from presently-advocated economic policies, or even from policies to stabilize the short-term business cycle. To the extent that the long-wave downturn is a consequence of overinvestment in physical capital, investment tax credits or rapid expansion of money supply by the Federal Reserve may provide little stimulus for investment. Alternatively, the primary impact of expansive monetary policy might be to defer, and eventually accentuate, the long-wave downturn. It is possible that the opposite policy of restraining monetary growth may lower inflation with little contractionary effect on output and employment. There may also be a possibility of cushioning the downturn by encouraging the diversion of resources from capital-excess areas arising from the long wave to areas of capital shortage such as energy production created by the life cycle of economic development. In other words, resources may need to be diverted to the energy sector in the future, even to maintain a constant production rate in the face of depleting fossil-fuel supplies. Such diversion can be accomplished successfully if we anticipate the impending capital excess and apply deliberate pressures to reallocate manpower and other resources. Alternatively, if unemployment radiating from the capital sectors is dealt with through increased welfare and unemployment compensation, reallocation of manpower will be effectively slowed. Such policies as described above are tentative proposals that need additional study, but they need to be considered if we are to manage the economy through the changes emerging from the long wave.

(6) *Coexistence of high inflation and unemployment.*—An explanation for the existence of simultaneous high inflation and unemployment in the U.S. lies in the three superimposed economic modes. First, unemployment and inflation may coexist if inflation is caused by increase in the money supply, unemployment is caused by reaching a peak in the long wave, and money supply has little effect on the long-wave fluctuation. Simultaneous high inflation and unemployment may also stem from a downswing of the long wave superimposed on life-

cycle pressures limiting growth, especially if money supply is expanded in an attempt to offset the recessionary forces. Such issues need further analysis and elaboration.

(7) *Limitations of the Phillips Curve as a guide to policy.*—Much of economic policy is predicated on the Phillips-Curve concept which implies the existence of a stable tradeoff between unemployment and inflation. Yet such a stable relationship between inflation and unemployment rate has seldom been observed in the real economy over long periods of time. The simple tradeoff concept is contradicted, for example, by the incidence of simultaneous high inflation and unemployment (see point #6 above). Perhaps the most serious shortcoming of the Phillips-Curve relationship is its interpretation as a general relationship between all sources of inflation and all sources of unemployment. Our work thus far indicates that the balance of inflation and unemployment in the economy depends in a complex way on the many modes of behavior in the economy as well as on the governmental policies being followed. For example, a simple Phillips-Curve relationship probably applies to wage changes, cost variations, and employment fluctuations that go on within the dynamics of the short-term business cycle. However, changes in money supply or changes in the position of the economy relative to the long-wave fluctuation will tend to cause shifts in inflation and unemployment that cannot be described in terms of simple movements along a fixed tradeoff curve. This implies that the Phillips-Curve concept is not a reliable indicator for public policy. The Phillips Curve needs to be broadened into a deeper understanding of the relationships between inflation and unemployment deriving from the interaction between the various modes of economic behavior.

(8) *Policies for the life cycle.*—Policies for adapting to the transition region of the life cycle will need to be developed in concert with stabilization policies for the business cycle and long wave. As suggested earlier, use of conventional monetary and fiscal policy may be more inflationary than stimulative in an era of growth restraints set by physical and social limits. New policies will be needed in areas such as energy, materials, agriculture, and water resources. For example, such new energy policies may include: encouraging lower energy use; reduced emphasis on expanding energy production as a means for balancing energy supply and demand; imposition of a high tax on consumption of nonrenewable energy; and increased efforts to understand the interrelationships between energy shortage and population and industrial growth.[35] Comparable policies will be needed in the other major areas of social and economic activity related to the life cycle.

(9) *Increased emphasis on policy rather than decision-making.*—Government actions in the next decades will need to be predicated in a strong policy basis that comes out of increased understanding of national economic dynamics. Such a policy focus is lacking in government at present. Many government actions are frequently termed "policy." For example, at a particular time Federal Reserve "policy" is to expand the money supply at a certain annual rate. But such a use of the term "policy" is a misnomer. A policy is an enduring rationale or decision rule that describes how a decision will be made

[35] See Forrester and Mass (1976) for detailed discussion of energy policy options.

under any possible set of circumstances. A policy can endure until the economic system is better understood and an improved policy has been determined. By contrast, decisions continuously change and are the action of the moment occurring as a consequence of applying the established policy to the changing conditions of the economic system. According to this viewpoint, an announcement by the Federal Reserve to expand the money supply at, say, 6% per year would be a decision rather than a policy. The underlying policy would state how the money supply should be managed in general in response to inflation rate, unemployment rate, and other conditions. But a clear statement of economic policy is lacking in most government agencies. More emphasis needs to be given to the underlying policy guiding government decision-making, and less emphasis to isolated decisions. In other words, how should we be responding to inflation, unemployment, and other difficulties, not just at present, but in general? Are generalized policy responses to inflation, such as monetary policy, effective in dealing with inflation arising from any cause? Will the same kinds of policies for dealing with normal business-cycle recessions be effective in combatting a downturn of the long wave? Such questions can be addressed through a broad focus on economic policy. A more sound and clearly-stated set of government policies will be needed in the future to guide government action and to prevent the misinterpretation of symptoms that can occur from confusion between the diverse modes of socio-economic behavior.

(10) *Increased research into the dynamics of the national economy.*—The policy directions summarized here represent only a starting point in developing improved management of economic behavior. Much additional work is needed to refine the analysis of the business cycle, long wave, and life cycle; to organize additional evidence for the resulting theories of economic behavior; to test the effects of alternative policies; and to disseminate results to a broad public audience. Economic problems confronting the nation are of sufficient magnitude to merit a large-scale commitment of government R & D funding to understand them better. Such work should be conducted by multiple groups using different methodologies in order to foster competition between groups and increase the likelihood of success. It is important, however, that the methodologies used be capable of dealing with long-term behavior; multiple modes of change; and feed-back interaction between economic, social, psychological, and demographic forces. Less emphasis should be on short-term forecasting and static analysis. With new efforts we can hope to achieve greater public understanding of prospects for economic growth and more effective government policies for responding to social and economic difficulties.

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LONG-TERM ECONOMIC GROWTH FORECASTS IN THE FEDERAL GOVERNMENT

By Joseph W. Duncan* **

Summary

This paper describes the major ongoing economic forecasting models developed by major Federal agencies. The sections describe the purposes of the models, their general approach, recent findings and relations to other modeling efforts. Three general points emerge from the review of ongoing efforts:

1. The major forecasts of the national economy are made by the Bureau of Economic Analysis of the Department of Commerce and the Bureau of Labor Statistics of the Department of Labor. Many other Federal agencies (including the Federal Energy Administration, the Environmental Protection Agency, the Economic Research Service of the Department of Agriculture, the Energy Research and Development Administration, the U.S. Department of the Interior, and the Federal Preparedness Agency) prepare long-term forecasts for more narrowly defined sectors of the economy.

2. There is a high degree of informal coordination between forecasting groups of various agencies, but there is a growing need for a more formal "Interagency Committee on Growth Models," which would meet on a regularly scheduled basis for the timely exchange of planning and implementation information and advice. The Statistical Policy Division of the Office of Management and Budget plans to establish this committee.

3. There is a strong feeling that the establishment of a central economic forecasting model would be counterproductive and too binding in developing helpful decisionmaking tools. One reason for this is that the purposes of each model are so diverse that no one model could serve them all. Another reason is that the tech-

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The conclusions and findings are not official views of the Office of Management and Budget.

The ad hoc committee members assisted in the review of sections concerning description of their agency models. The overall conclusions and findings are the views of the author and were not subjected to agency concurrence since this has been prepared as a background document for future policymaking.

**This paper was prepared with editorial help from Judith Strenio (Harvard University) while she was serving as a research intern in the Statistical Policy Division (SPD) of the Office of Management and Budget (OMB). David Hulett, Chief of the Economic Statistics Branch, SPD, assisted throughout the meetings of the Ad Hoc Committee on Long-Term Growth Models. (See attendees listed in appendix II.) Agency contributors to this report are: T. M. Albert, Energy Research and Development Administration, Alvin A. Cook, Jr., Federal Energy Administration, Daniel H. Garnick, George R. Green, and A. Ray Grimes, U.S. Department of Commerce, Ronald E. Kutscher, U.S. Department of Labor, Calvin O. Lawrence, Environmental Protection Agency, and Lenore Sek, U.S. Department of the Interior.

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nical difficulties of interface between separate models are such that a central model would not be efficient.

I. Introduction

The development of long-term economic projections is not a new activity; there have been several long-term economic forecasting efforts, including the Paley Commission in 1952 and the Interagency Long-Term Growth Project in the early 1960's. Recently, however, the interest in long-term growth projections has accelerated. The Statistical Policy Division of the Office of Management and Budget, with its responsibilities for establishing statistical policy for all Government agencies, has recognized the appetite of long-term modelers for improved statistical series. As a result, an Ad Hoc Interagency Committee on Long-Term Growth Projections was established in 1975 to review existing efforts in Federal agencies, to identify areas of common interest, and to examine policy options for improved coordination and integration of some of the various models. Much of this report is a result of this Committee's work.

At the outset, it is appropriate to recognize the limitations and difficulties of long-term economic forecasting. In a recent report, Data Resources, Inc. (DRI) discussed several sources of instability in the economy at present including the disequilibrium of the international relations system, the world commodity situation, the legacy of double-digit inflation, the rapid changes of relative prices, and the overall financial condition of the economy. DRI concluded that:

> Under these circumstances, it is very difficult to develop serious long-range plans for government and business. Economic planning is offered as one of the solutions to our difficulties. There are long-range matters which deserve better attention from our government. But increasing frequency of shocks and the continued uncertainties make it totally inappropriate to draw up elaborate plans which assume that the future can be known. The rational strategy for businesses and governments in an environment such as this one is quite different: to develop quick responsive capabilities to new shocks as they may come along, and to devise policies which at least partially insulate institutions and systems from the many sources of instability.[1]

Thus, in discussing and evaluating long-term economic growth projections, one must always keep in mind the fact that, under the present economic instability, the best forecasting efforts may not be accurate enough in retrospect. However, it is important to try to forecast the impact of current Government actions and outside events on the level of economic activity as a whole, on individual sectors and regions of the economy, and on the Federal budget in particular. Some guide to the potential effect of proposed programs derived from long-term forecasting can be an important policy tool when used in combination with other factors in comparing the impact of several possible alternative programs. Thus, the present use of long-term economic projections lies more in contributing an additional analytic dimension to the decisionmaking realm than in the area of actual knowledge of the future.

A list of several of the agencies presently involved in long-term projections illustrates the present scope of such activities within the Federal Government. The Economic Growth Branch and the Regional Economic Analysis Division of the Bureau of Economic Analysis of

[1] Quoted from Data Resources, U.S. Long-Term Review—Summer 1975 in "National Energy Outlook: February 1976," Federal Energy Administration, FEA–N–75/713, pp. B–1 to B–3.

the Department of Commerce, the Economic Growth Division of the Bureau of Labor Statistics of the Department of Labor, the Economic Research Service of the Department of Agriculture, the Federal Energy Administration, the Energy Research and Development Administration, the National Science Foundation, the Environmental Protection Agency, various Bureaus of the Department of the Interior, and the Federal Preparedness Agency of the General Services Administration all engage in long-term forecasting at some level. They have participated in the review of existing efforts presented in the next section.

The following modeling efforts are covered in some detail:

1. BEA Growth Model.
2. BLS Economic and Employment Projections Model.
3. The OBERS Program (BEA/ERS).
4. The ERS Economic Projections Program.
5. Federal Energy Administration Forecasts.
6. Energy Research and Development Administration Projections.
7. Environmental Protection Agency/SEAS.

II. National Long-Run Economic Growth Models

BEA Growth Model

The Bureau of Economic Analysis (BEA) of the Department of Commerce is engaged in continuing development of, and projections with, a moderate sized annual growth model of the U.S. economy. The BEA Model provides a medium-term [2] projection of GNP and its components, productivity, inflation rates, income items, and other aspects of the national economy. The BEA group maintains communications with other governmental units interested or involved in related work, especially the Bureau of Labor Statistics (BLS), in arriving at assumptions to be used for the projections work.

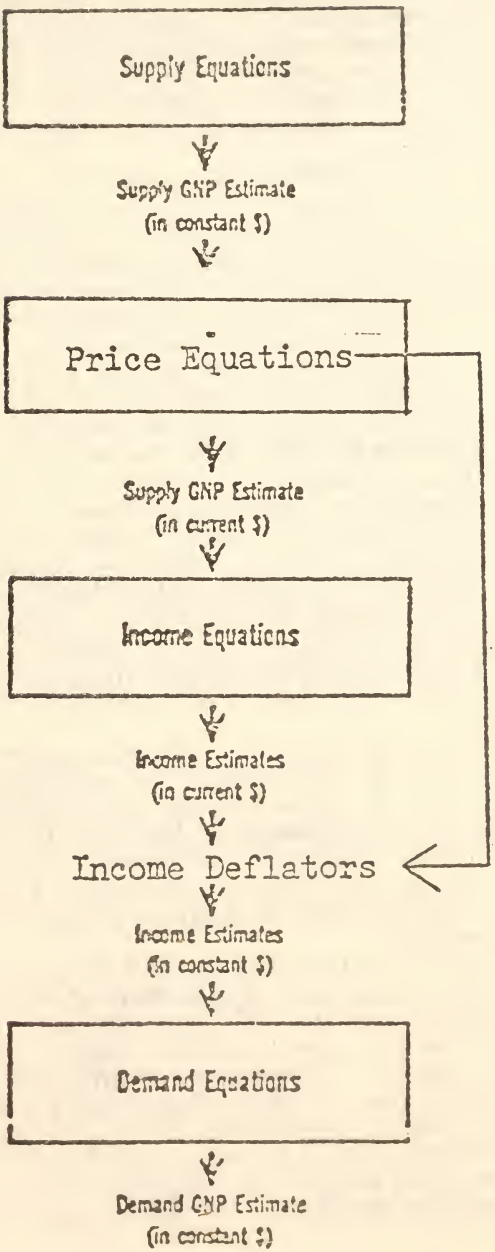
Methodology of BEA Growth Model.—A simplified flow chart of the model which identifies major sectors, but abstracts from the simultaneity in the model, is shown as Figure 1. The original model specification appeared in the June 1969 Survey of Current Business, although the model currently in use has been improved considerably from the beginnings described there.

The current model contains four principal sectors—supply, prices, income, and demand. The supply equations estimate the GNP that could be produced with different quantities of capital and labor. This is the GNP necessary to achieve an unemployment target, given labor force assumptions derived from population estimates. The price equations provide estimates of the overall GNP deflator as well as component deflators. These are used to inflate the supply GNP estimate for the income sector and to deflate the income estimates which enter into the determinations of the demand sector. The income equations estimate the various components of aggregate income. They are used to derive the distribution of income that is consistent with the supply estimate of GNP. Given the income flows and the price values, the

[2] Recent uses of the model have involved projections to 1985, although the model has been used for projections as far out as 2000.

FIGURE 1

Simplified Flow Diagram of Model



In equilibrium: Demand GNP (in constant $) = Supply GNP (in constant $)

Source: U.S. Department of Commerce, Bureau of Economic Analysis.

demand equations estimate the endogenous final demand components (Federal purchases, which represent fiscal policy decisions, and exports are exogenous; that is, supplied to the model from outside judgments or data).

Summing the elements of demand provides the demand side estimate of GNP, which need not equal the supply estimate. If the two are not equal, the unemployment target is inconsistent with the specified fiscal policy package. To eliminate this "gap," the fiscal policy input can be reformulated and the specified unemployment target maintained or the unemployment rate can vary to equate supply and demand with given fiscal policies.

Recent Conclusions of BEA model.—The BEA econometric growth model was designed to provide medium-term projections of the U.S. economy and to aid in the formulation and analysis of fiscal policies.

A model run is currently in progress, but the results will not be available until late November or early December 1976. As of November 1975, the most recent conclusions from this effort were:

1. After recovery from the recent recession, the U.S. economy will experience slower rates of growth in real GNP and productivity than in the full employment period 1964–1969. This is a consequence of a number of factors including: a slowing in the rate of growth in the labor force due to a shift in the age composition of the population; the growing amount of nonresidential, fixed investment for pollution abatement which can hamper productivity growth to the extent it substitutes for investment in productive capital; and some shift in the industrial mix of GNP towards industries with lower levels of labor productivity.

2. The U.S. economy will continue to experience relatively high rates of inflation reflecting both the increase in unit labor costs associated with lower productivity growth and the high wage increases which result from attempts to catch up with past price increases.

3. Given the assumption that the 1975 tax cuts for persons and corporations will be extended and that no additional tax cuts will occur, the most significant change in the distribution of income from the historical pattern is the decline in the ratio of disposable personal income to total personal income. As a result of the progressive Federal tax system and the projected inflation rates, the effective average Federal personal tax rate increases significantly over the period.

4. The composition of final demand shifts somewhat over the period. The personal consumption share of GNP declines reflecting the reduction in the real disposable personal income share. The nonresidential, fixed investment share increases as a result of the additional investment expenditures necessary to comply with pollution abatement requirements and to reduce dependence on foreign sources of petroleum. Though the total Government share of GNP continues to decline as it has for the past several years,[3] the State and local share continues to move higher, reflecting BEA's assumption of continued growth in Federal grants-in-aid.

[3] Federal purchases of goods and services declined from 11.4 percent of GNP in 1967 to 7.8 percent in 1973. A slight increase occurred in 1974 and 1975.

5. Even with modest growth in Federal spending programs, sizeable budget deficits will result through 1980 as the economy slowly recovers from the recent recession.

Uses of the BEA Model.—The model is currently being used to make medium-term projections of GNP and its components. In addition, the model has served several useful applications within BEA including an analysis of the sensitivity of the economy to changes in various fiscal policy instruments and the analysis of capital requirements for full employment production. Also, the model projections are used to assist other units within the Department of Commerce and other Government agencies in their analyses of future economic conditions, including:

1. An analysis of the sources and uses of gross saving in the 1970's, for the Assistant Secretary for Economic Affairs;
2. The implications of the existing tax structure for saving, investment and economic growth through 1985, prepared for the 1974 Economic Summit Meetings; and
3. Projections for the period 1970 to 2000 to analyze the economic effects of widely differing assumptions about the rate of population Growth and the American Future and the Department of State (for submission to the U.N. 1975 World Population Conference).

BLS Economic and Employment Projections Model

The program of economic growth studies in BLS develops 5- to 15-year economic and employment projections of the U.S. economy in industry detail. Recent projections have involved 125 industries. The projections involve a detailed study of the growth of the U.S. economy under alternative scenarios, embodying assumptions about Federal economic policy and other factors which shape the future economic environment.

Methodology of BLS Model.—The BLS projections are developed using the following sequence:

1. Labor force projections are developed using population projections for various age and sex groups developed by the Bureau of the Census.[4]
2. Potential GNP is projected as the product of: (a) employment, based on the projected labor force and the assumption of percent unemployment; (b) projected annual hours per job; and (c) projected output per man-hour.
3. Distribution of potential GNP into major categories of demand is projected through the use of a macroeconomic model which starts with potential GNP and develops estimates of Government revenue, personal income, and business income. The income estimates are then used to develop projections of Government purchases of goods and services, personal consumption, and investment expenditures. Assumptions about changes in Government fiscal policy are incorporated so that a satisfactory balance of demand and supply GNP are achieved. The macroeconomic

[4] The latest labor force projections were contained in Johnston, Denis F., "The U.S. Labor Force Projections to 1990," Monthly Labor Review, July 1973, pp. 3–13. These will be updated by a release planned for August 1976.

model used by BLS is the same model described earlier in the BEA Growth Model section.

4. Conversion of projected demand into detailed industry employment estimates is done in three substages:

(*a*) Major final demand components (i.e., consumption, investment, Government demand) are distributed into detailed projections of demand by industry.

(*b*) The potential demand for all final goods and services is converted into industry output requirements through the use of inter-industry (input-output) relationships projected to 1980 and 1985; and

(*c*) Projected industry output is derived and subsequently converted into employment requirements based on projections of annual hours per job and output per man-hour.[5]

In the late 1960's the Interagency Growth Project (consisting of BLS, BEA and OMB, and chaired by the President's Council of Economic Advisers) guided and funded the development of a basic projection model by Dr. Lester Thurow, then at Harvard. Both BLS and BEA have enlarged and modified this basic model to reflect their separate needs for detail and focus in economic projections. They maintain close communications to ensure comparability of results from the two models in the sense that, given the same fiscal policy assumptions, the models will project the same growth rates of GNP and the same unemployment levels.

Frequently, their uses of the models differ in that BLS sets an unemployment assumption and modifies the fiscal policy assumption to achieve the assumed level of unemployment. BEA's model can be used this way, but BEA generally assumes various proposed fiscal policy packages and observes what the resulting unemployment rate would be for each.

Recent Conclusions of BLS Model.—The latest BLS projections are in the March 1976 issue of the Monthly Labor Review.[6] The most recent projections were revisions of projections published in a 1975 report entitled "The Structure of the Economy in 1980 and 1985." Some of the conclusions reached in these projections are as follows:

1. In the period 1973–1985, overall real GNP growth will be slightly lower than the 1955–1968 rate. This 1973–1985 rate reflects a somewhat more rapid rate of growth for 1980–1985 than for 1973–1980. However, because of the 1973–1975 decline in GNP the projections show a growth in real GNP during 1975–1980 of 5.8 percent a year to reach a 5.5 percent unemployment level by 1980.

2. Employment projections show a moderation of the growth of government employment at all levels but particularly for State and local governments, with a corresponding increase in the rate

[5] Source: U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 1831 (1975), "The Structure of the U.S. Economy in 1980 and 1985," pp. 2–3.

[6] Kutscher, Ronald E, "Revised BLS Projections to 1980 and 1985: An Overview," Monthly Labor Review, March 1976, pp. 3–8. Bowman, Charles T. and Morlan, Terry H., "Revised Projections of the U.S. Economy to 1980 and 1985," Monthly Labor Review, March 1976, pp. 9–21. The Bureau fo Labor Statistics has recently revised its labor force projections to 1990 These revisions are not reflected in these economic and employment projections described here In general the new labor force projections would call for a modestly higher rate of economic growth in the 1980's but amounting to less than .1% a year.

of growth of private sector employment. Employment and labor force growth will slow down in 1980–1985.

3. The shift in employment toward services and away from goods-producing sectors is expected to continue. Agriculture, though projected to decline severely in the 1973 predictions, has now been projected to decline much less than before, a change brought about by increased demand as a result of the new world food outlook. Mining (previously projected to decline) in the latest projections shows modest growth due to a change in the energy outlook, requiring a higher rate of coal production and oil exploration.

4. Federal receipts are projected to grow more rapidly than expenditures, but under the fiscal policy assumption used a small deficit is still projected for 1985. The rate of growth of State and local expenditures is projected to increase at slower rates than experienced in 1955–1973.

Two more articles describing revision of the 1973 projections will appear by the end of 1976 in the Monthly Labor Review. An article in the August 1976 issue of the Monthly Labor Review will review in detail the accuracy of the 1970 projections prepared by BLS.[7]

Uses of the BLS Model.—Attention is given to labor force and productivity growth, capital and material requirements, and changes in technology and the patterns of demand from individuals, governments, business and foreigners. Projections of output levels as well as labor and material requirements are currently made using a 125-sector disaggregation of the U.S. economy. In addition, staff capabilities, data bases and models developed for the projection effort are regularly employed to estimate the impacts of various Government programs, legislative proposals, and other current or anticipated developments which may affect distribution of demand, rate of economic growth, or level and distribution of employment.

The major use of the projections within the Department of Labor is to supply an economic and manpower framework upon which estimates of future occupational requirements are made. The Bureau of Labor Statistics regularly publishes detailed information on the outlook for employment is a large number of occupational categories.

The projections have also been used within the Labor Department and other parts of the Federal Government as a framework for assessing a number of diverse economic problems such as capital requirements, manpower utilization and energy policy. In addition, several State and regional agencies, private research groups and business organizations have used the projections as a "national" framework within which to develop their own, generally more disaggregated, projections. In order to make the projections as generally available as possible, a large amount of detail is published and, in addition, historical and projected data bases are made available on computer (magnetic) tape.

[7] Personick, Valerie A. and Sylvester, Robert A., "Evaluation of BLS 1970 Projections," August 1976, Monthly Labor Review forthcoming. The BLS projections were in Projections 1970, BLS Bulletin 1536.

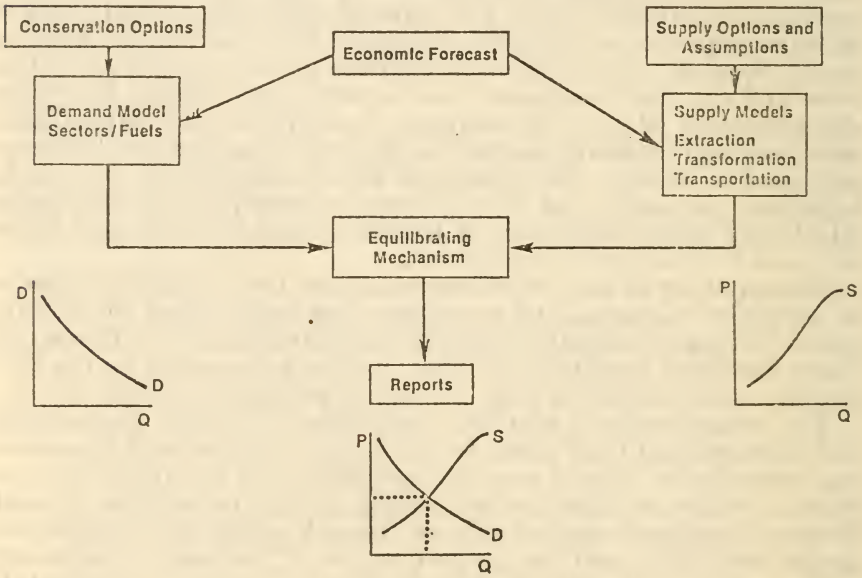
Federal Energy Administration Forecasts

Long-term Federal Energy Administration (FEA) projections are made through the Project Independence Evaluation System (PIES). This system generates planning estimates depicting possible states of the energy system.

The model is used in two ways: (1) to help the Administrator of FEA in his policy role by analyzing the impact of various energy policies and (2) in developing a set of projections of what the energy picture will be in the future. The principle result of PIES is the determination of equilibrium prices and quantities of energy by type and region at specified future time points, based on specified alternative energy policies.

Methodology of PIES Projections.—A flow chart representation of PIES (shown as Figure 2) is found in the *National Energy Outlook: February 1976*,[8] FEA. The central portion of the system estimates the energy supply and demand which are integrated to make the forecasts in an iterative way.

FIGURE 2.—Basic PIES flowchart.



Source: "National Energy Outlook: February 1976," FEA, p. A–4.

Input into these forecasts is of three types: (1) general indicators of economic activity such as GNP, inflation, and unemployment from an external macroeconomic model; (2) constraints to be imposed upon the system such as limits on material and equipment, capital, labor and transportation; and (3) foreign energy prices and domestic energy policies.

[8] Op. cit., Figure A–3, p. A–4.

The macroeconomic inputs are not forecast by FEA; in the past they have been taken from forecasts generated by the large-scale macroeconometric model developed by Data Resources, Inc. The constraint inputs are a matter of judgment combined with as much hard information as can be gathered, but no mathematical analysis is used to generate them. The use of a macroeconomic model in conjunction with an energy-specific model such as PIES helps assure continuity between the energy sector and the rest of the economy.

Output from the central computation models comes in the form of some 20 reports in the areas of economic impact, international assessment, and environmental impact assessment as well as the actual forecasts.

The original purpose in developing PIES was to generate some quantitative analysis about energy to use in the *Project Independence Report*[9] of 1974. But the purposes for which it is, and can be, used go far beyond that one-time report. This is possible because of the flexibility built into the system including: (1) the ability to incorporate constraints; (2) the ability to assume new technological capabilities; and (3) the ability to incorporate judgments into the analysis and to analyze the sensitivity of the results to the accuracy of these judgments. The model also incorporates responsiveness to changes in relative prices and analysis of externalities.

Recent Conclusions of PIES.—The most recent predictions generated by the PIES system are contained in *National Energy Outlook: February 1976*,[10] published by the FEA.

The major findings and conclusions of that report are:

1. Over the next 10 years, the Nation can greatly expand its domestic energy production and cut the rate of growth in energy demand and still meet its economic objectives.

2. The post-1985 prospects for maintaining independence are less certain unless technological and economic breakthroughs occur.

3. Specifically, by 1985, as a result of higher prices, energy demand will be much lower than historic growth rates and an active conservation program could further reduce energy demand.

4. As for new supplies, Alaska will be the greatest source of new oil production. Nationally, projection is made difficult by a lack of knowledge about the amounts of reserves available.

Uses of PIES.—The PIES system is used extensively by the Administrator of FEA in the task of defining and shaping proposed energy policies. The quantitative analysis was pervasive in the preparation of the original *Project Independence Report* and is used by the Administration and the Congress as the primary tool for evaluating energy initiatives. For example, it is used to forecast the effect of proposed legislation (e.g., gas deregulation) in the energy area.

Essentially, any policy question that can be stated in terms of changes in supply and demand curves, modification of energy conversion and distribution technologies, or constraints on the energy supply system can be examined in great detail through the PIES

[9] Project Independence Report, FEA, GPO No. 4118–00029, November 1974.
[10] *Op. cit.*

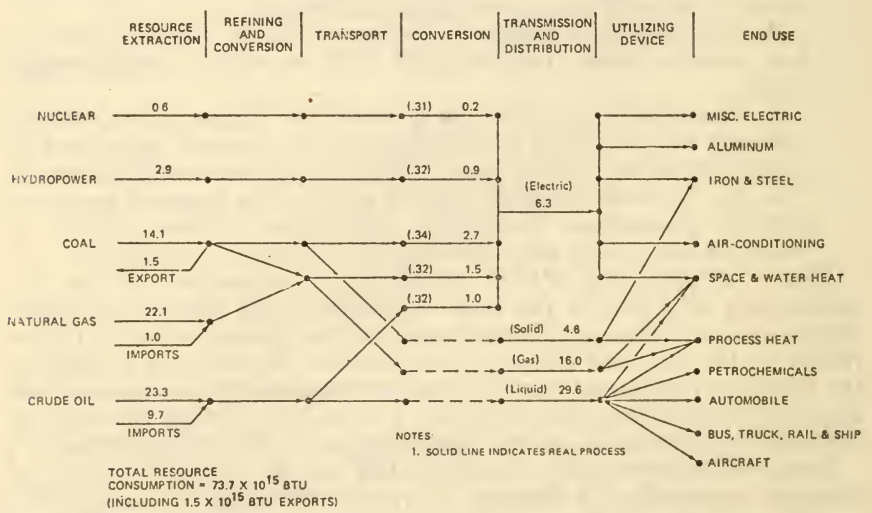
system.[11] The system is focused upon the energy sector alone, without intent to interact with other sectors. However, for analysis outside the energy field, the system is used to develop parameters for use in other models. For example, a proposed energy policy might imply a large investment in energy supplying sectors. One could then go outside PIES to other models to evaluate the impact of this form of investment upon the economy.

Energy Research and Development Administration (ERDA) Projections

Energy-related projections have been published as a part of "A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future."[12] These projections are the product of a system created for ERDA by the Brookhaven National Laboratory (BNL), which uses as its macroeconomic framework the Data Resources, Inc. projections. The projections, which are for the years 1985 and 2000, include total energy demand, imports required, electricity used, and other factors of the national energy system, projected under a variety of scenarios.

Methodology of ERDA Projections.—BNL's system deals with future energy demand in terms of key end-use categories (for example, space heating and transportation) that are constant for a given test of scenarios. The demands are specified not in terms of fuels, but in terms of services required of energy end-use devices (passenger miles to be driven, square feet of floor space to be heated and cooled, tons of steel to be made). The services can be met for each scenario with

FIGURE 3.—Reference Energy System 1972.



Source: ERDA 48, Vol. I: The Plan, p. IV–3.

[11] Hogan, William W., "Energy Policy Models for Project Independence," Discussion Paper, June 18, 1975, FEA, to appear in the Journal of Computers and Operations Research.

[12] ERDA–48, Vol. I: The Plan, GPO No. (1975) 0–579–905. More recent projections are contained in ERDA–76–1; A National Plan for Energy Research, Demonstration, and Development: Creating Energy Choices for the Future: 1976, Vol. I: The Plan, GPO No. (1976) 052–010–00478–6.

several different mixes of fuel and electricity, depending on the technology assumed. The system then examines the set of potential technologies and energy resources specified within a scenario and chooses that mix of fuels and technologies which will both meet the service requirements and minimize the total system-wide cost. It assumes that any computed shortfall of domestic energy inputs will be made up by imported fuels. A diagram is shown as Figure 3.[13]

Although the most recent report available to the writer of this paper was ERDA–48 (on which the above model description was based), more recent results have been published in ERDA–76–1. These are based on an expanded model, which is described in a spring 1976 paper prepared by Brookhaven National Laboratory (BNL).[14]

This new analysis links detailed mathematical process engineering and economic models to more aggregate econometric models. The four models which are used are:

1. The BNL engineering model, used to estimate physical flows within the energy sector;
2. The BNL/University of Illinois input-output econometric model, used to link general economic transactions to the engineering model;
3. The DRI interindustry model, used to analyze general economic structure and the interaction between energy and the rest of the economy;
4. The DRI macroeconomic growth model, used to specify the long-run trends of U.S. economic growth.

The use of an expanded interaction between econometric and engineering models is the new feature for the ERDA analysis, and provides a much more detailed capacity to analyze the economic impact, in a broad sense, of various alternatives in energy research and development. The linkage of the four models is not completely automated yet, but work is going forward to do that before the next set of ERDA projections is made.

BNL has developed several other capabilities for their energy and economy models. These include:

1. Technology assessment—assuming a given set of available energy technologies, which one would be used?
2. Time tracing—if a certain technology were introduced, what time path would its usage rate follow?
3. Timing assessment—if solar energy were economically viable in 1990, would nuclear power ever be needed?

Recent Conclusions of ERDA Model.—In the Plan, submitted in June of 1975, projections are shown for six scenarios: (1) no new initiatives; (2) improved efficiencies in end-use; (3) synthetics from coal and shale; (4) intensive electrification; (5) limit on nuclear power; (6) combination of all new technologies.

In the most pessimistic scenario (developed only as a reference point), current use and technology are assumed to continue unchanged; in this case, total annual consumption reaches 164 Quads (1 Quad = 10^{15} BTUs) in the year 2000, and projected oil imports are 13 million bar-

[13] Ibid., pp. IV–3.
[14] The Relationship of Energy Growth to Economic Growth under Alternative Energy Policies, by David J. Behling, Jr., Robert Dullien, and Edward Hudson, available from National Technical Information Service/U.S. Department of Commerce/5285 Port Royal Road/Springfield, Virginia 22161.

rels a day in 1985 and 28.5 million barrels a day in 2000. These projections contrast with the current level of about 6.5 million barrels a day. This scenario is clearly unacceptable, and overly pessimistic since it is highly unlikely that *no* new initiatives will be taken.

At the other end of the scale, assuming all new technologies are developed leads to the most optimistic projections. This scenario shows total energy consumption at about 130 Quads in the year 2000, with a surplus of two million barrels of oil per day. From this it can be concluded that if all technologies were pursued, successful, and fully implemented, it would be possible to meet our energy requirements with domestic supplies. Unfortunately, this scenario is an ideal which is also very unlikely.

These projections and those of the more likely intermediate scenarios are not predictions of future energy use, but rather they represent possible patterns which may emerge from the research and development and other energy policy decisions made now.

Uses of ERDA Model.—Projections of the energy system in 1985 and 2000 based on various scenarios have been used extensively by ERDA in developing the substance of their *Plan for Energy Research, Development, and Demonstration.* Implications of various alternatives, such as (1) conserving energy by developing greater efficiencies at end-use or (2) extracting more coal and oil from current locations by developing more effective recovery technology, are examined in terms of projected imports, demand, and other facets of the energy system. The results suggest which approaches are best for long-term and intermediate-term periods.

III. Regional Long-Run Economic Growth Models

The OBERS Program (BEA/ERS)

The Regional Economic staff of the Bureau of Economic Analysis has a separate projection effort in cooperation with the Economic Research Service (ERS) of the Department of Agriculture to produce area economic projections of population, employment, personal income, and earnings for 37 industry groups. BEA produces the major economoic projections, while ERS produces only the agricultural parts of the projections.

This subnational projection program was begun at the request of, and with financing by, the U.S. Water Resources Council which uses the projections to assess water resources requirements and to evaluate programs. The projections involve a combination of econometric modeling and judgment.

Methodology of OBERS.—In order to make area economic projections, projections of population, employment, and income are made first for the Nation and then disaggregated geographically. The projections of area population are derived from the projections of area income and employment on the assumption that persons in the labor force migrate to areas of economic opportunity and away from areas of economic decline or stagnation. Crucial assumptions used in making the forecasts include an unemployment rate of four percent during the projection years by decade to 2020, and the assumption that there will be no policy or program changes of an unusual nature or magnitude.[15]

[15] "State Projections of Income, Employment, and Population to 1990," Survey of Current Business, April 1974, p. 26.

Recent Conclusions of OBERS.—The following conclusions can be drawn from recent projections[16] (which omit post-1971 events such as the world shortages and rapidly rising prices of fossil fuels and grain):

1. During the 1970's and 1980's, the Southeast, Southwest, and Rocky Mountain States are projected to grow at above-average rates; the Far West and New England States are projected to grow at near-average rates; and the Mideast, Great Lakes, and Plains States are projected to grow at below-average rates.

2. The rapid growth projected for the Southeast and Southwest is a continuation of past trends (for the Rocky Mountains, it is a reversal). Manufacturing will continue to boost southern growth, but much of the growth will occur in chemicals, machinery, fabricated metals, paper, printing, and other manufacturing rather than in the currently dominant textile and apparel industries. In addition, a continued influx of retirees and vacationers, mainly to Florida and Arizona, will spur income growth in these States.

3. The near-average growth projected for the Far West States contrasts with the rapid growth of the past. This change in trend began in the late 1960's, with the cutback in the space program and declining military and civilian aircraft production. In addition, the crowded conditions and the resulting environmental damage that developed in parts of California have discouraged immigration.

4. The below-average growth projected for the Mideast and Great Lakes States reflects the likely continuation of the tendency for U.S. manufacturing to become more dispersed geographically. The growth performance of the Plains States will continue to be shaped by the slow growth of agriculture and food processing.

Uses of OBERS.—Other Federal agencies (most of which have funded extensions of the projections program) and their uses of the projections are:

1. *Council on Environmental Quality*—for preparing environmental impact statements,

2. *Department of Transportation*—for assessing transportation needs,

3. *U.S. Postal Service*—for projecting mail volume and evaluating Post Office capacities,

4. *Federal Energy Administration*—for assessing the area impacts of energy policies,

5. *Winter Navigation Board* (an interagency authority)—for studying the impact on industrial location patterns of extending the Great Lakes-St. Lawrence Seaway shipping season,

6. *U.S. Army Corps of Engineers and Tennessee Valley Authority*—for addressing specialized problems in local area planning, and the

7. *Environmental Protection Agency*—for estimating waste water facility needs by area.

In addition to these uses by Federal agencies, these long-term area economic projections are in heavy demand by State and local governments, universities, and private business organizations (including

[16] 1974 OBERS Projections: Regional Economic Activity in the U.S. (Series E Population), seven volumes (U.S. Water Resources Council, 1974); and Area Economic Projections: 1990, a 1974 supplement to the Survey of Current Business.

major construction-related, transportation, and marketing concerns, banks, and private economic and engineering consulting firms). At least 38 State governments have contacted the Federal project team to discus the projections and their uses. Many of the Government units use BEA projections as a starting point in preparing intermediate-term economic outlooks and in evaluating the economic impact of proposed Government projects or private investment.

The ERS Economic Projections Program

The agriculture portion of the OBERS projections are furnished by a larger program within ERS. When ERS was reorganized in 1973, the National Economic Analysis Division (NEAD) was given responsibility for developing an additive, ERS-wide Economic Projections Program with a quick-response capability. They have developed the core of the National-Interregional Agricultural Projections (NIRAP) system which provides OBERS data as one of its functions.

Methodology of NIRAP.—The NIRAP system is a computerized simulation of the food and fiber system, with a 10-year horizon for most projections. It can simulate alternative futures based on scenarios differing with respect to major uncertainties which have an impact on food and fiber, and with respect to policy decisions and programs designed to alleviate specific problems. By systematic scenario development and comparative analysis of alternative futures, the range of possible adjustment paths for food and fiber can be bracketed, an early warning of potential difficulties provided, and possible solutions to potential problems and trade-offs between policy goals evaluated.

The NIRAP system is still being enlarged and improved. Extensive intra-ERS coordination, with all program areas of ERS having input into what assumptions are made and how the model works, characterized the development and use of the model.

Uses of NIRAP.—Each year, the NIRAP system is expanded to encompass a broader spectrum of the food and fiber system. A core set of scenarios is revised and resulting projections of alternative futures are analyzed to provide a continual check on major issues and to provide current projections for analytical extensions of the core program. For example, the core program is used by ERS to support periodic national assessments of water and related land use resources needs and individual commodity or input subsector studies. Also, studies are conducted for special purposes such as appraising the U.S. production capacity for food and fiber and providing the food and fiber projections for broader general economy studies conducted by other agencies or research groups.

IV. Long-Run Environment and Energy Growth Model

Environmental Protection Agency/SEAS

The Environmental Protection Agency (EPA) established the Strategic Environmental Assessment System (SEAS) [17] It is a collection of interdependent models used to forecast the state of the environment which would result from alternative environmental policies and socioeconomic trends. Forecasts are presented annually through 1985.

[17] It should be noted that the President's Budget for fiscal year 1977 contains no funds or personnel for the SEAS project.

The socioeconomic trends are predicted outside the SEAS system, and the environmental policy alternatives are, of course, generated by decisionmakers in EPA.

Methodology of SEAS.—The SEAS structure is modular in nature, consisting of 28 computational and input-output computer programs. Any program may be executed independently of the others. All programs are autonomous in the sense that they do not require mandatory user-supplied information. That is, the mandatory input files all exist within the system with default values that a user can override if he wishes. The modules include: national economic modules, including macroeconomic forecasts, subsector growth and technological change; abatement cost; and national residuals. Other available modules include stocks of critical resources of materials, solid waste types, disposal methods and costs, transportation, energy used by fuel type and user category, and a set of models which permit regionalization of national economic and pollutant residual data. A flow chart of the system is shown as Figure 4.

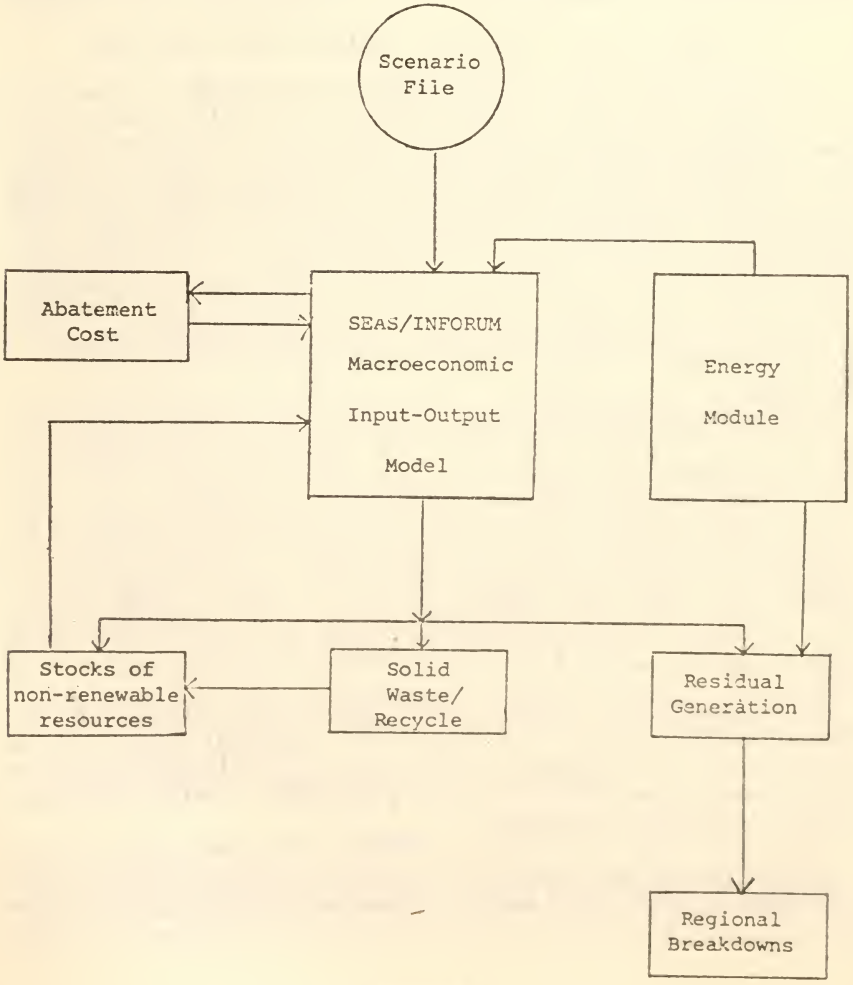


FIGURE 4

Recent Conclusions of SEAS.—The most recent major SEAS forecasting effort is not yet published, but the review process is nearing completion and it will be published as a Report to Congress on the Cost of Air and Water Pollution Control: 1976–1985. Six separate scenarios were analyzed and the results will be available in the Report.

Uses of SEAS.—SEAS is also used on smaller-scale projects, both by other divisions of the EPA and by other agencies. Within the EPA, the Offices of Energy, Minerals, and Industry is making use of SEAS. The Office of Solid Waste Management Programs has used SEAS to forecast impacts of auto recycling alternatives and its Industrial Sludge Task Force adapted SEAS to provide comprehensive input for much of its analytic effort. The annual report of 1974 of the Council on Environmental Quality contains forecasts generated by SEAS. The National Commission on Water quality was another user agency. The Bureau of Land Management (Department of the Interior) offshore drilling evaluation relied on SEAS to support determination of the onshore environmental impact of such drilling along the New York/New Jersey coast.

V. Model Users: Treasury, OMB, CEA, and FRB

The discussion in this paper has focused primarily on long-term economic growth models built and utilized by the Federal Government from a model builder's perspective. Many governmental groups use long-term forecasting as input to their decisions, as a basis for policy advice to the President, or even to make projections of their own, without actually developing a large econometric model within their own agency. Examples include the U.S. Department of the Treasury, the Federal Reserve Board (FRB), the Office of Management and Budget (OMB) and the Council of Economic Advisers (CEA). Each for reasons that vary finds it impractical to develop an internal long-term model, but uses the results of other modeling efforts to shape views of the future.

Each agency has different needs for long-term projections and different ways of dealing with those needs. The CEA, for instance, is an advisory group for the President. It is asked for expert opinions on complicated economic questions, usually with a very short time to develop these opinions. Because the questions it investigates are so diverse, a model suitable for all of them would be unfeasible. Instead of attempting to build an in-house model, they rely on many existing efforts, both public (BEA, BLS) and private (DRI, Wharton, Chase). This works well because different models are well suited to answering different questions, and CEA is able to draw on the strengths of each model.

Each year the CEA, Treasury and OMB develop five-year projections of major economic variables (such as national output, rate of inflation and unemployment rate); however, the longer range economic assumptions are "mechanical" projections or extrapolations as noted in the budget documents.

CEA and OMB's use of models offers an illustration also of how long-term models and analyses affect policy decisions. In CEA's case, a question is posed whose answer requires long-term projections. The

question may be of the "what would be the effect?" variety. By running the proposed fiscal actions as a scenario on an appropriate model or on two models and combining their results, such a question can be answered fairly accurately.

Some of the more special-purpose models; (e.g., the energy-related models of FEA or ERDA) can be used in a similar way to answer "what if?" questions. Also, the projections obtained from using assumptions based on what the policymaker considers as most likely can be used as input for policy on how to cope with this situation. A third way models can be used by policymakers is to show what actions must be taken now to achieve a particular policy goal. Thus, in the "Project Independence Report," the policy goal was the achievement of energy independence. The PIES model enabled policymakers to evaluate what steps would best encourage that goal by showing how much independence we would gain and how quickly under various possible energy policies.

The existence of several large-scale long-term modeling efforts in Government is thus useful to the polymakers of the agencies involved and also to those of other agencies.

VI. Coordination of Modeling Within the Federal Government

Since mid-1975, the Ad Hoc Interagency Committee on Long-Term Growth Models, chaired by the Statistical Policy Division of OMB, has met on several occasions to exchange information on existing modeling efforts and to discuss potentials for improved coordination. These discussions and the material presented earlier have highlighted three important points:

1. *A great deal of informal communication already occurs between modeling teams as a result of the need to find solutions to complex problems.* Hence, a set of outputs from one model frequently becomes useful input to a second model focused on a different set of issues, so that the models are often complementary rather than redundant.

2. *An Interagency Committee on Long-Term Growth Models is appropriate, with regularly scheduled meetings to assure that information exchange occurs on a timely basis.* The Ad Hoc Committee suggested an interest in improved coordination through a standing and active committee to enhance the collaboration which currently occurs on an informal basis.

3. *The diverse objectives of agencies require considerable freedom in specifying model objectives and selecting methodological approaches.* Thus, the Committee feels that a single central model would not be an effective way to meet the Government's needs for long-term analysis.

These points are elaborated in the next sections.

1. *Informal Coordination*

The selected projects described in this paper illustrates the diversity of existing Federal Government efforts to develop long-range models and related analysis in selected key policy areas. These models

have not all been developed independently, and it is important to review the ways in which the models and the model development efforts of different agencies are related. When long-range modeling was first initiated through the Interagency Growth Project, it was clearly a coordinated approach involving continuing participation of key agencies, especially BEA and BLS. Over time, as the program matured and the critical methodological issues were resolved, the efforts became more specialized, with primary attention being given to refinements of procedures and the production of updated versions of the results.

The BEA model projections also incorporate projections of other Government agencies for a number of the necessary exogenous inputs. For example, the Bureau of Census population projections and the labor force projections of the Bureau of Labor Statistics are significant inputs to the demographic assumptions in the BEA model. Also, BEA consults the Social Security Administration, the Civil Service Commission, the Department of Defense, and the Bureau of the Census for projections of Social Security developments and retirements of Federal, State, and local government employees.

Coordination between the Interagency Growth Project and other agencies generally takes the form of informal technical exchanges. In many cases, these exchanges provide valuable insights which enhance the quality of the projections. For example, BLS has recently held discussions with the Commerce Department's Regional Economics Division, the Federal Energy Administration, and the Environmental Protection Agency in order to help provide consistency in the macroeconomic environment assumed for the different studies and to avoid duplication of effort.

The OBERS project is another program which was developed as a cooperative effort. This one involves BEA and ERS of Agriculture, as discussed in the previous section. The term OBERS, in fact, is an acronym derived from BEA's former title, the Office of Business Economics (OBE), and ERS. OBERS also directly uses Census population projections by age and sex group and the Bureau of Labor Statistics' projections of the labor force by age and sex group as the national controls for projections of related data.

Another example of close coordination is that the ERDA projections made by Brookhaven National Laboratories and the FEA/PIES projections are checked for consistency as far as 1985, the farthest year for which FEA makes projections.

The EPA development of SEAS involved extensive informal interagency coordination. Biweekly planning meetings were held at which various elements of the design of certain modules were discussed. They produced much helpful input into the design of SEAS and helped make the system well suited to analyses in other agencies. Several State governments were also actively involved in the planning and development of the regional breakdown module of SEAS to ensure the accuracy and usefulness of the reports generated on a regional basis.

The Interior Department programs involve varying degrees of coordination. The Minerals Availability System has coordinated with the Geological Survey in collecting supply data and uses demand projections from outside the system. The study *U.S. Energy Through*

the Year 2000 draws extensively on all information available from other agencies, including the FEA, FPC, and FTC. The recreation site forecasting project uses Census and OBERS projections. The Continental Shelf program uses some energy forecasts from the Bureau of Mines and the PIES study and some analysis done by SEAS.

So throughout the area of long-term forecasting, extensive and rather successful coordination is found—in both formal and informal terms.

2. *Interagency Committee on Long-Term Growth Models*

Although a great deal of informal interagency communication now takes place, the discussions of the Ad Hoc Committee demonstrated that a formal committee would be extremely helpful. Its most important function would be to facilitate the exchange of information between model builders at several levels. Meetings could be organized around particular issues of interest to all long-term economic growth modelers. Such topics include what population projections are available and how they were arrived at, what range of productivity assumptions are reasonable, and other discussions of data or assumptions that are essential to nearly all models. These discussions should occur at regularly scheduled intervals and are likely to be primarily of interest and value to the technicians who are actually building and running the models.

An active and continuing Interagency Committee should also have a larger role to play in relation to major users of the models. This would involve coordinating and emphasizing the policy purposes and user needs for the models. There should be periodic meetings of the policymaking users both within the Departments of Commerce and Labor, and outside users such as CEA, Treasury, and the Federal Reserve Board to explore specific uses of existing models. This would result in an exchange of ideas and greater utilization of the available models. These meetings should also focus on unmet needs that users have—a discussion which could be very helpful to the model builders in their efforts to improve the usefulness of their models.

There are other tasks this Committee may wish to undertake. One is the publication of a User's Guide to Long-Term Growth Models in the Federal Government. Another task might be to survey public and private model users to discover unmet needs. A third function could be defining data gaps—types of data which many models require, yet which are not currently available.

As a result of the discussion of these ideas by the Ad Hoc Committee, the need and desire for a formal interagency committee became plain. Since the needs for improved data and data standards were clearly a direct product of such a committee, the Statistical Policy Division of the Office of Management and Budget agreed to establish an Interagency Committee on Long-Term Growth Models as a continuing activity with regularly scheduled meetings. These meetings will be designed to assure a more intensive effort to share data needs and results and to serve the needs of model users.

3. *Problems With A Single Central Model*

While the importance of improved coordination in modeling efforts is evident, it was a clear consensus of the Ad Hoc Interagency Committee that it would be inappropriate and, in fact, counterproductive to attempt to achieve a single general-purpose model and single standard set of assumptions to meet the needs of all the different agencies. In fact, most participants believe that pluralistic analysis and conflicting assumptions strengthen the opportunities for effective policy debate, and that a restriction of assumptions or methodology raises a high risk of sterilizing that debate.

There are three major difficulties that stand in the way of a central model. One is the diversity of needs evidenced by model users. To build a central model with sufficient labor force detail for BLS use and energy sector detail for ERDA, etc., would be unfeasible. The second problem is the technical impracticality of trying to generate data in great detail from one model in one agency to be used as input into a specific sector model in another agency. The details of data transfer are difficult enough when the transfer is between two programs in one computer. The agencies of the Federal Government not only have different computers, but different models and types of computers, so the problems involved in data transfer alone would make a single central model extremely expensive. The third difficulty is the fact that while fiscal assumptions may be standardized for some purposes, in other cases the end product desired is fiscal impact of the other assumptions and analysis. Hence it would be inappropriate to require use of standard fiscal assumptions when the purpose is to increase the fiscal effect of other variables. This conflict between inputs in one case being outputs in another case is found throughout the variables used in the various models.

While rejecting the practicality of a single model, the Ad Hoc Committee discussions stressed the importance and value of a formal interagency committee in performing a centralizing role. For example, consensus values of GNP growth or labor force size could be reached which most modelers would feel comfortable in using, at least as baseline figures.

It should be noted, however, that if the Committee were to develop consensus values and assumptions that would be guides for individual models, these would change over time as knowledge of events changes. This process of adjustment is common to all forecasting efforts, even in fields as well understood as demography. Between 1967 and 1975, changes in fertility rate trends have caused the projected 1990 population to be lowered by 20 percent in the category of people born after 1965. Similarly, the abundant energy assumptions concerning economic growth made a decade ago have been largely replaced by the energy-constrained assumptions that characterize current estimates. So even agreed-on assumptions will change over time, and any effort to reach cosensus estimates must be designed to be highly flexible and subject to frequent modifications. Hence, it seems inevitable that different reports by different agencies at different times will result in diverse projections of the future.

Appendix I. Other Modeling Efforts

Throughout the Federal Government many agencies prepare projections about small sectors of the economy with which they are directly concerned. One example is furnished by the Federal Preparedness Agency of GSA which develops projections of future needs for various critical materials in order to determine proper amounts to stockpile.

Another example is the Department of the Interior. Within the Department there are several long-range projection programs. These are all single-sector efforts. Some can be used as policy analysis models to see the effect on particular sectors of certain policy alternatives, but most are basically attempts at projection based on current programs.

Department of the Interior: Bureau of Mines/Mineral Availability System.—The Bureau of Mines has two projection programs. One is the publication every five years of *Mineral Facts and Problems*, a publication surveying the minerals industry and containing production and demand forecasts for each commodity to 1985 and 2000. The demand forecasts are based on general economic forecasts from outside the Bureau of Mines, but the production forecasts are made utilizing the Bureau's Minerals Availability System which takes data about current resources of specified minerals and using engineering knowledge about costs and manpower, equipment, and other requirements, determines what resources would be needed to meet the demand and what the price would be. The system is expected to show resource limitations which are often neglected in econometric models.

Department of the Interior: Bureau of Mines/Energy Projections.—Another project at the Bureau of Mines is the study *U.S. Energy Through the Year 2000*. This study draws extensively on all information available from other agencies. The major conclusions show that the U.S. will continue to be dependent on imported petroleum. Nuclear energy will increase and natural gas will decrease in relative significance. Initially, coal will be more important, but that relative importance will decrease with time.

Department of the Interior: Regional Electricity Forecasting.—The other Interior programs are not major analytic efforts. They are all single-sector and regional projections. The Bonneville Power Administration (BPA) prepares regional forecasts of population, employment, and economic activity for the purpose of determining future electric power requirements in the Pacific Northwest. The BPA forecasts are combined with those of other utilities in the region and then used to plan for new regional generation and transmission facilities. Individual utilities use the combined forecasts to plan their area distribution systems, their need to participate in generating facilities, and for rate and revenue studies.

The forecasts show varying degrees of economic growth for the subregions, but the general area is expected to show continued growth of 11.8 percent (1970–1980) and 17.3 percent (1980–1990).

The Alaska, Southwestern, and Southeastern Power Administration are involved in similar long-term forecasts of regional power loads.

Department of the Interior: Recreation Site Forecasting.—The National Park Service forecasts public use for the next 10 years of areas administered by the Service. The forecasts are used in planning for facility and program expansions as well as indicating the extent and probable growth of the Nation's leisure industry. Area planners use Park Service information to estimate the pecuniary and nonpecuniary benefits to recreation users and local and regional businesses. Forecasts indicate a significant upward trend in park use despite large increases in travel costs in recent years. The National Park Service plans to emphasize alternative modes of transportation within parks as a means of diminishing the undesirable effects of automobile congestion.

Department of the Interior: Bureau of Land Management/Continental Shelf.—As part of the Outer Continental Shelf program, the Bureau of Land Management (BLM) examines onland regional impacts of offshore drilling for energy resources. These analyses use forecasts of the national economy, mostly contracted outside the Government, as input.

Appendix II. Attendees of the Interagency Group on Long-Term Growth Projections [18]

Central Intelligence Agency

Charles Boykin, Guy Caruso, James Froeschle, and Michael Maddox.

Congressional Budget Office

Allan Ruchman, and Kendrick W. Wentzel.

Council of Economic Advisers

Jeff Green, Michael D. McCarthy, Valerie Sarris, and George von Furstenburg.

Department of Commerce

John Cremeans (BEA), Daniel H. Garnick (BEA), George R. Green (BEA), A. Ray Grimes (BEA), Gary S. Hansen, Richard Mullins, and Edward R. Williams.

Department of the Interior

Dan Edwards, Gary Kingston, Barbara Lloyd, Lenore Sek, and Robert Wilson.

Department of Labor (Bureau of Labor Statistics)

Charles T. Bowman, Ronald E. Kutscher, and Thomas Mooney.

Energy Research and Development Administration

Ted M. Albert, Cliff Patrick, Phil Patterson, and Richard H. Williamson.

Environmental Protection Agency

Peter House, and W. Randall Shobe.

Federal Energy Administration

Brad Askin, Alvin A. Cook, Jr., Don Eldridge, and Mike Gaffen.

Federal Reserve Board

Stephen P. Taylor, and Helen Tice.

General Services Administration (Federal Preparedness Agency)

Ron Hurdelbrink.

National Science Foundation

Russell C. Drew, Carl Leopold, William J. Montgomery, and Ernest Powers.

Office of Management and Budget

Ahmod Al-Samarrie, Joseph W. Duncan, David T. Hulett, Cary Leahey, John Merck, Jerry Shipley, Arnold Strasser, and Judith Strenio.

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ERS Contact—Leroy Quance/Economic Research Service Coordinator for Projections/National Economic Analysis Division/Economic Research Service, U.S. Department of Agriculture/Room 248/500 12th Street, S.W./Washington, D.C. 20250 (447–7681).

Department of Commerce, Bureau of Economic Analysis Growth Model

Main Reference—Thurow, Lester C., "A Fiscal Policy Model of the United States," pp. 45–64, *Survey of Current Business*, Vol. 49, #6, June 1969.

BEA Contact—George R. Green/Assistant hCief, Business Outlook Division and Acting Chief, Economic Growth Branch/Bureau of Economic Analysis/U.S. Department of Commerce/1401 K Street, N.W./Room 1204/Tower Building/Washington, D.C. 20230 (523–0701).

[18] This listing includes all who attended one or more meetings of the group. Many only attended one meeting which was of special interest to them.

Department of the Interior, Projections and Programs

Interior Contact—Barbara Lloyd/Department of the Interior, Bureau of the Mines/Room 8027/2401 E Street, N.W./Washington, D.C. 20240.

Department of Labor, Bureau of Labor Statistics Growth Model

Main Reference—*The Structure of the U.S. Economy in 1980 and 1985*, Appendix A, U.S. Bureau of Labor Statistics, Bulletin 1831 (published 1975).

BLS Contact—Ronald E. Kutscher/Assistant Commissioner/Office of Economic Growth/Bureau of Labor Statistics/Room 4531, GAO Building/441 G Street, N.W./Washington, D.C. 20212 (523-1450).

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